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REINFORCED-CONCRETE VIADUCT ON THE RICHMOND AND CHESAPEAKE BAY RAILWAY, RICHMOND, VA.

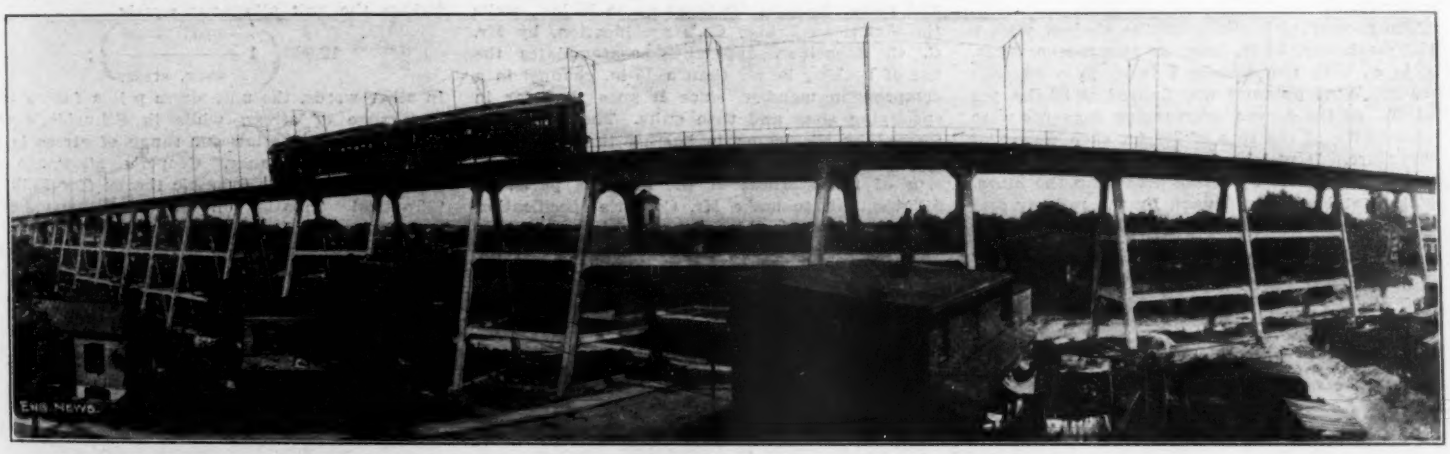
The Richmond and Chesapeake Bay Railway is an electric line extending from the city of Richmond, Va., to Ashland, a distance of 16 miles. Ultimately it will reach tidewater at Chesapeake Bay. The entrance into Richmond is made through a closely populated district, cut up into numerous short blocks, where a series of grade crossings would have been highly undesirable, so the line is carried for a distance of 2,800 ft. over a viaduct at some places 70 ft. from the street level. Although the first design for the viaduct was in timber, some of the material for which had been obtained, considerations of fire protection and of economy in maintenance persuaded the company to undertake a reinforced-concrete structure. Bids for the design of such a structure were therefore asked, the railroad giving only the general location and profile and the loads required. Under these conditions the design of the Trussed Concrete Steel Co., of Detroit, was accepted. This design, based on the Kahn System of Reinforced Concrete, is novel for so large a structure; it is probably the first reinforced-concrete viaduct of any size which has been built. The work was carried on in the summer and fall of 1906, and the viaduct is now carrying the traffic according to the best expectations of its designers.

The viaduct consists of a series of interbraced and battered bents, varying from 14 to 70 ft. in height, and carrying the track on two parallel girders, varying in span from 23.5 to 67.4 ft. It is built throughout of reinforced concrete, the Kahn reinforcing bars being used. Fig. 2 is an elevation of the structure, the portions omitted being principally the regular 23.5 and 33-ft. spans with the longer spans up to 67.4 ft. at street crossings. The alinement and grades are indicated on this figure; there are two 7° curves, and the crossings at many of the streets are on heavy skews, in some places as high as 32°. For the greater part of its length the line is single track, but from Marshall St. south a double track is provided. As it is supposed that a double track line will some day be needed, provision has been made for a future enlargement of the width of the roadbed by building the footings, for all bents over 21 ft. in height, with an offset column base to which new columns can be attached. In lower bents new foundations will be built, but openings have been left in the old work into which the horizontal struts and braces will fit.

There are in general four types of cross-section in the viaduct; the single-track line, under 21 ft. in height, at right angles to the line of track, and with no provision for future connections at the footings; the single track line, over 21 ft., with footing connections; the skew single track line; and finally the double track line. These four sections are shown in Figs. 3-7; their reinforcing and other details are simple and easily understood from the drawings.

The special points of interest in the structural details are the large girder beams and the use of concrete beams as struts. The columns have no distinctive features over any other reinforced-concrete column. Although originally designed for hooping they were built square, reinforced only with the regulation winged Kahn bar. The connection at the bottom is made by a tenon fitting into a mortise left in the footing together with dowel rods running some 4 ft. up into the column. The struts are square beams, designed as columns, rigidly connected with brackets to the bents. The girder beams vary in span from 23 ft. 6 ins., with a section of 12 × 30 ins., to a span of 67 ft. 4 ins. and a section 22 × 60 ins. This latter beam is shown in Fig. 7. It will be noticed that the regular rectangular section did not provide enough compression area so a small bracket was added at the top.

The track consists of 80-lb. rails, spiked to 8 × 8-in. cross ties, which are bolted to sleepers, 6 × 12-in. on tangents and on the inner tracks of curves and 12 × 12-in. on the outer curves, thus giving an outer elevation of 6 ins. These sleepers are embedded in the concrete girders. Bolts were set in the concrete, with every sixth bolt projecting through the tie and sleeper and the others through the sleeper only. To facilitate the setting of sleepers and ties and to prevent the bolts rusting off, 2-in. holes were bored and afterward filled with cement mortar. Cross-ties are dapped 1½ ins. over sleepers, and are placed 12 ins. on centers. Every fifth cross-tie is 4 ft. longer than the others, and to it is nailed planking, which serves as a sidewalk 40 ins. wide. This arrangement of the roadbed was primarily designed to provide a cushion against the transmission of vibration and impact into the structure, and has proved highly acceptable in both tests and actual service. The outer guard rails are 8 × 12-in. timber; the inner are 80-lb. rails.



VIEW OF REINFORCED CONCRETE VIADUCT ON THE RICHMOND & CHESAPEAKE BAY RY., RICHMOND, VA.

Expansion joints have been provided where the short girders rest on the brackets; at distances from about 125 ft. at the low bents to about 200 ft. at the high ones. These joints consist of steel bearing plates upon which the girders can slide, together with steel toggle connections at the upper part of the girder. This joint is detailed in Fig. 9.

A concrete mix of 1 part cement, 2 parts granite dust and 4 parts crushed granite to pass through a ¾-in. ring was used throughout, with the exception of in the footings, where a 1: 2½: 5 mixture was used. With a mortar made of cement and James River sand, a tensile value of 220 lbs. was reached at 7 days, and 415 lbs. at 25 days; whereas the same cement plus an equal amount of the granite dust used on the work gave 400 lbs. in 7 days and 480 lbs. at 25 days. Six-inch cubes of the above mixture gave 2,075 lbs. per sq. in. in compression at the end of 20 days. Although at first the work was carried on from two permanent mixing plants at oppo-

TABLE SHOWING DEFLECTIONS UNDER TEST TRAIN ON VIADUCT OF THE RICHMOND & CHESAPEAKE BAY RAILWAY COMPANY.

Span between bents.	Deflect. of girders, in feet. Right.	Left.	Span.	Deflect. in proportion to length of span. Right.	Left.
0-1	.018	.018	49	1/2688	1/2688
1-2	.008	.008	23.5	1/2937	1/2937
2-3	.010	.010	23.5	1/2350	1/2350
3-4	.010	.010	23.5	1/2350	1/2350
4-5	.011	.009	23.5	1/2136	1/2611
5-6	.012	.007	23.5	1/1958	1/3357
6-7	.013	.011	23.5	1/1808	1/2136
7-8	.009	.011	23.5	1/2611	1/2636
66-67	.008	.008	33	1/4224	1/4224
68-69 (Clay St.)	.016	.008	67.4	1/4314	1/8628
72-73	.010	.010	26	1/2496	1/2496
82-83 (Marshall St.)	.013	.013	67.4	1/5176	1/5176

site ends of the work, it was afterward found that one plant transferrable from one place to another could lay much more material. This plan was then followed.

The columns were designed for a compressive stress of 500 lbs. per sq. in. The girders were proportioned for an extreme fiber stress of 600 lbs. per sq. in., assuming continuous beam action, and 50% allowance for impact regardless of the length of span. Steel in tension was figured at 16,000 lbs. per sq. in.

The foundation is a very good stiff clay, occasionally mixed with gravel. The footings were proportioned for a bearing value of 3 tons per sq. ft. for all possible stresses; also including future double-tracking. Bottoms of all footings were made 4 ft. below grade, unless a greater depth was required for a good foundation, when they were carried down as directed by the chief engineer.

The prescribed loadings on the viaduct were a 150,000-lb. car, 54 ft. long, on two trucks, 33 ft. c. to c., with two wheels, 7 ft. c. to c. on each truck. Wind pressure was figured at 30 lbs. per sq. ft. At the curves, overturning moments were allowed for at the rate of 2% for each degree of curvature. It will be noted that the outer footings have a greater bearing area than the inner.

The test load agreed upon by the railway and the contractor consisted of a locomotive and tender preceded by two 150,000-lb. gondola cars, the loads spaced as shown in Fig. 11. The first test consisted in running this train, headed by the locomotive, the full length of the viaduct. It was then run back, and the deflections measured for several spans. A test was then made by breaking the train at various portions of the viaduct. The last test was running the train at a speed of over 35 miles per hour. In all, the test train made seven trips. The accompanying table gives the deflection with its ratio to span of various girders. It will be noted that the maximum deflection is 0.018-ft. on a 49-ft. span. At curves the inner girders have a greater deflection than the outer, which would be equalized when rounding the curve at speed.

The work was designed in the New York office of the Trussed Steel Concrete Co., under the direction of Mr. Benj. J. Greenhood, to whom we are indebted for the information and illustrations herein presented. The contractor was Mr. John T. Wilson, of Richmond and New York.

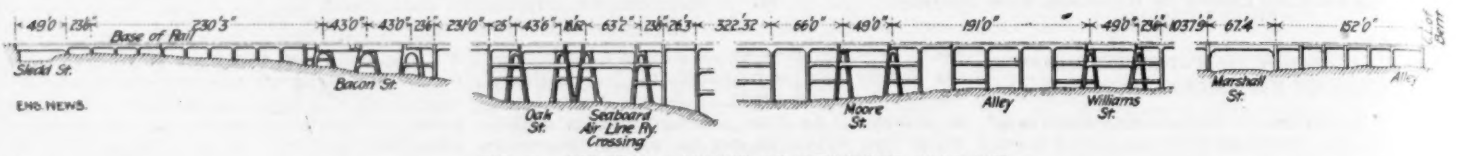


FIG. 2. GENERAL LAYOUT OF RICHMOND VIADUCT.

WORKING-STRESSES IN STEEL CONSTRUCTION.

By C. A. P. TURNER,* M. Am. Soc. C. E.

The failure of the great Quebec bridge under construction, while primarily due to badly proportioned compression members, has with reason raised question relative to some features of general specifications and their applicability to structures of extraordinary size. To take first some minor points:

Column Reduction.—The failure of the specification adopted for this structure to make any reduction in compressive working stresses where l is less than 50 r, is not in accord with common practice. Again, its failure to require an additional reduction for the unsupported length of the section of the column between points of attachment of lacing, would seem a defect yet to be remedied in all published specifications with which the writer is familiar.

Latticing.—Cooper's specification provides that the size and spacing of lattice bars shall be duly proportioned to the size of the members, and gives the sizes for posts up to 15 ins., while the American Bridge Co.'s specification, by Mr. C. C. Schneider, apparently contemplates the use of nothing larger than a 15-in. channel in a compression member, since it goes that far in specifying sizes and then quits. The work performed by the lacing in holding the parts of a compression member in line is an inverse function of the stiffness of the separate parts. It follows that, to make Mr. Cooper's specification explicit, we must add some qualifying conditions as to the make-up of built channels, such, for example, as requiring the width of flange to be not less than 25% of the depth of web, and the area of both flanges not less than 40% of the total area of the section.

Distribution of Metal.—To prevent local buckling the limitation of the total depth of web to 35 times its thickness, and the cover plate to 40 times its thickness, would insure reasonable proportions, proportions corresponding with those used in the tests upon which column formulas are bases.

The too frequent use of T-sections in which a long thin web is considered effective, should be discouraged by allowing not more than 12 thicknesses to be figured at full value, and specifying that all extra width is to be allowed for on the following basis: 80% of the added area for the first additional thickness in width, 60% for the second, 40% for the third, etc., so that the use of excessively wide unsupported strips of cross-sectional area, to which common formulas do not apply, will be discouraged.

Having noted above some of the minor but essential points which have generally been disregarded in bridge specifications, let us proceed to investigate some more radical differences.

A COMPARISON OF ALLOWED STRESSES.—Compare, for example, Cooper's specifications with those of Mr. C. C. Schneider for highway bridges. Mr. Cooper allows for live-load, 12,000 lbs. compression reduced for column length, and for dead-load, 24,000 lbs. per sq. in. Mr. Schneider allows for both live and dead-load, 17,000 lbs. per sq. in. reduced for column length, with an impact allowance for live-load which in effect reduces the actual allowed live-load stress. In the railroad bridge specifications of these two engineers, Schneider allows 17,000 lbs. per sq. in., impact included; Cooper allows 10,000 lbs. per sq. in. for live-load, and 20,000 lbs. per sq. in. for dead-load; these unit-stresses applying to tension, and, reduced for column length, to compression. In the specification for the Quebec Bridge the unit allowance equals

$$12{,}000\left(1+\frac{\text{min. stress}}{\text{max. stress}}\right);$$

in other words, the unit-stress p is a function of the range of stress, while in Schneider's the only attempt to allow for range of stress is in the impact allowance. Cooper's allowance is based upon Fidler's dynamic theory (see Fidler's "Practical Treatise on Bridge Construction") and in practical application is similar to the Quebec requirement, based on the deductions of Launhardt and Weyrauch from the Wöhler experiments.

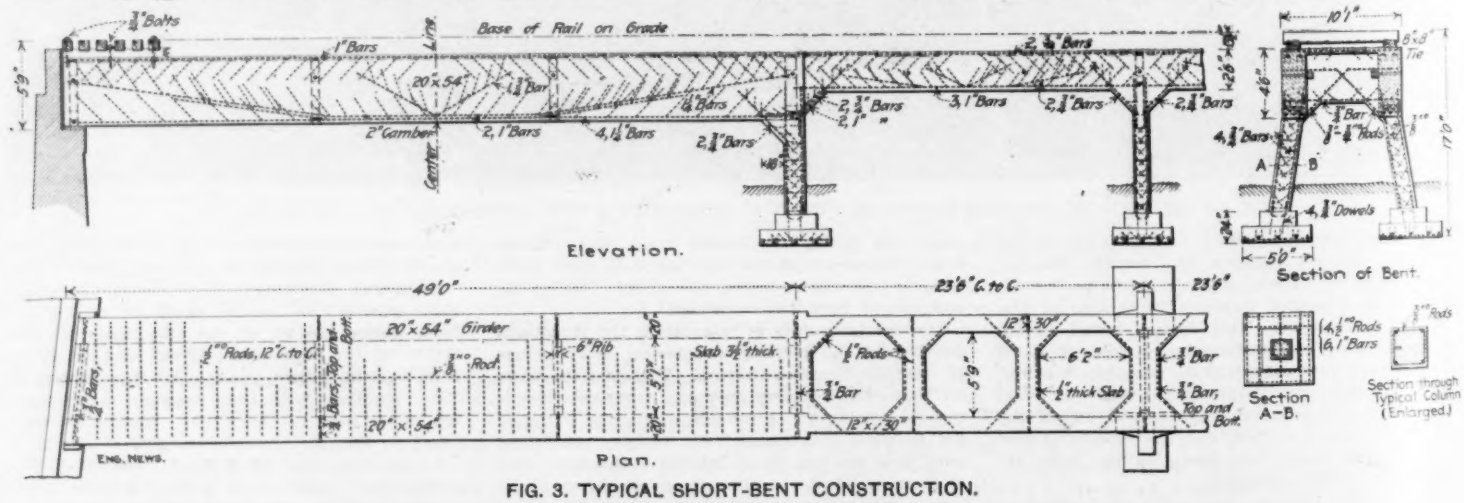


FIG. 3. TYPICAL SHORT-BENT CONSTRUCTION.
(The plan is typical of all the work.)

Let us compare the resulting stresses under Schneider's, Cooper's and the Quebec Bridge formulas, for chord A10 of the Quebec bridge design. For the first we have,

$$I = S\,\frac{300}{L+300}$$

Where I = impact to be added to the live-load stress S = maximum live-load stress, L =

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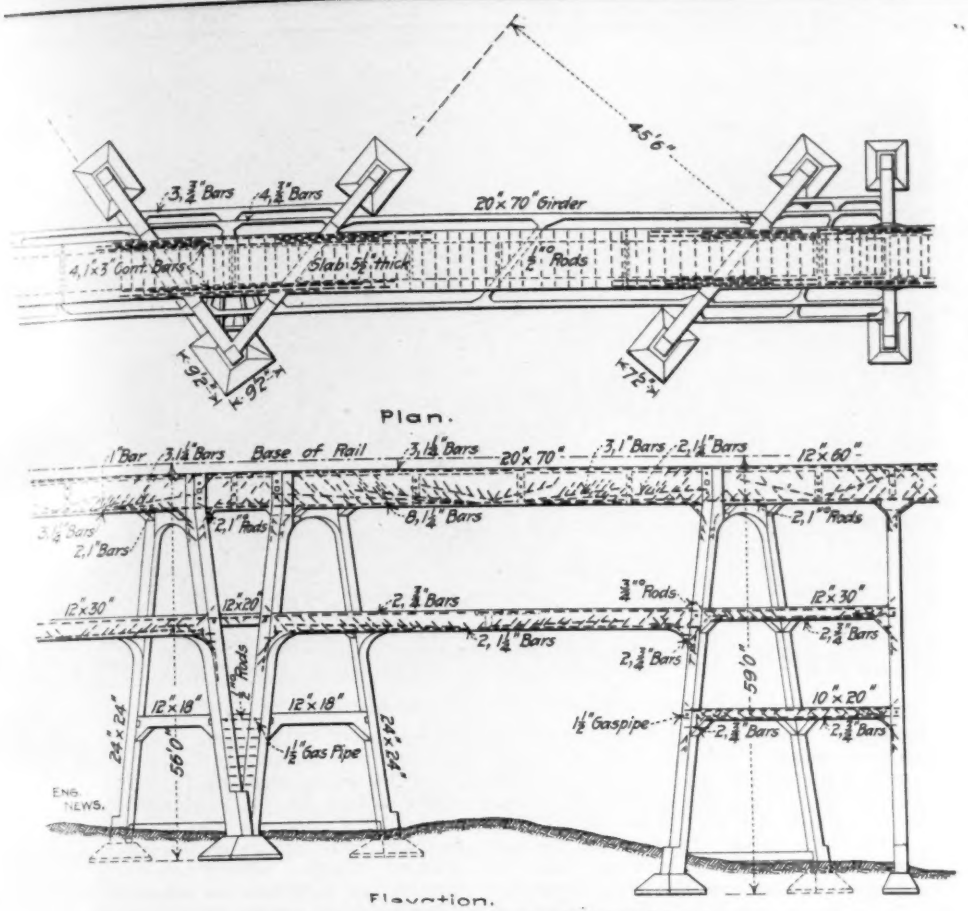

FIG. 4. TYPICAL SKEW CONSTRUCTION.

length of loaded distance in feet which produces the maximum stress. Then

$$I = S\left(\frac{300}{300 + 1040}\right) = S\,\frac{1}{4.5}$$

and

LL	=	4,246,000
I	=	950,000
DL	=	11,883,000
Total	.....	17,079,000

If $p = \dfrac{17{,}000}{1 + \dfrac{l^2}{11000\,r^2}} = 14840$ the area required for dead and live-load is 17,079,000 ÷ 14,840 = 1,150 sq. ins. Add for wind, combined with dead and live-loads, and we have 1,230 sq. ins. required for dead-load, live-load and wind. Figured under Cooper's railroad bridge specification, a little greater area results. These sections are over 60% greater than those called for in the Quebec design.

Taking up the center top chord and comparing sections by the three formulas, we find that the Quebec Bridge specification gives a section nearly 30% lighter than the other two, while at the anchorage the section is only 5% lighter than under Schneider's specification.

Let us now refer to the working stresses adopted by Fowler and Baker for the Forth Bridge. (See "Engineering," Feb. 28, 1890.) For tension members the steel was to have an ultimate resistance of not less than 30 nor more than 33 tons (English tons) per sq. in., with an elongation in 8 ins. of at least 20%. For compression members the steel was to have a resistance of not less than 34 nor more than 37 tons per sq. in., with 17% elongation. With regard to varying stresses: for a load varying between zero and a maximum, 20 tons per sq. in. to be assumed as the ultimate strength if the change occurs frequently and 22½ tons if occurring rarely. For stresses alternately tensile and compressive, 10 tons if frequent and 15 tons if seldom, one-third the assumed ultimate strength to be taken as the working strength.* It may be noted that these stresses are about the same as Mr. Schneider's for the same grade of steel; that the variation for range of stress is only 12½% for stresses of one kind against 100% in the Quebec Bridge specification. Figuring the Quebec design on the basis of the Forth Bridge specification, and taking the center top chord, we have 1,040 sq. ins. against 710.8; main tie next to the end, 550 sq. ins. against 450, and the bottom chord A10 about double the section that was used in the Quebec Bridge.

Evidently where there are such extreme variations in working stresses in the sections, there must be something radically in error in the conception upon which some of these working stresses are based.

*These figures are in pounds: tension steel, 67,200—73,920; compression steel, 76,160—83,880; repeated stress, effective strength, 44,800—50,400; alternating stresses, effective strength, 22,400—33,600. The working stresses then are: tension, 22,400 lbs. per sq. in.; compression, 25,390; repeated stress, 14,930—16,800; alternating stresses, 7,470—11,200.—E4.

THE RANGE-OF-STRESS FALLACY.—In the early days of testing when methods at the disposal of the investigator were crude, indeed, it was supposed that the elastic limit was at the point where permanent set resulted from straining the specimen. When Wöhler made his historic investigation showing that a smaller load and smaller number of repetitions of stress or loading were required to break a specimen, the greater the range of loading, it was assumed (in view of the fact that the ultimate strength so found for a considerable range of stress, from plus to minus, was below the value then recognized as the elastic limit) that the range of stress must necessarily be taken into consideration in any rational design. Launhardt and Weyrauch are to be credited with taking into consideration the bare facts presented by this

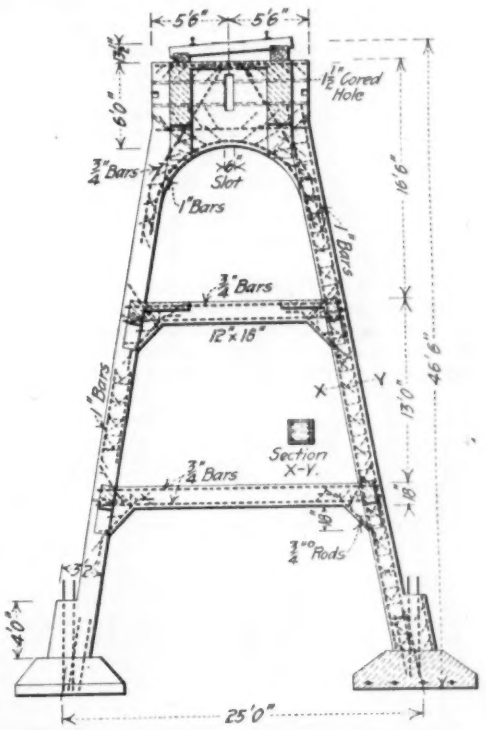

Fig. 5. Typical High Bent, with Provision for Future Widening.

work and that of other investigators and therefrom working out an empirical formula which, in a measure, fitted the results, a formula which assumed that the working stress must rationally be based upon such a conception of the ultimate strength of the material.

This latter assumption would be true unquestionably, were it a fact that in the specimens broken under Wöhler treatment the range of stress had been confined within the true elastic limit of the metal. If the fact can be demonstrated to be otherwise, by showing that these experiments upon which are based the so-called rational formulas merely add to our knowledge of the deportment of material *beyond* the true limits of elasticity and have no relation whatever to the effect of range of stress *within* these limits, then we may condemn these maximum-and-minimum formulas as a most dangerous premise upon which to work out a safe and secure design. If it can be shown that the results of fatigue tests may be accounted for by the range of the loading *beyond* the true limits of

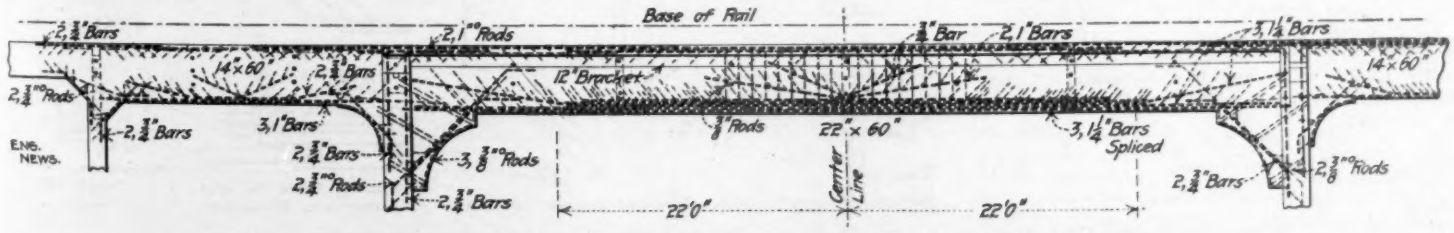

FIG. 6. DOUBLE-TRACK CONSTRUCTION, RICHMOND VIADUCT ELEVATION.

elasticity, then it would seem that any effort to determine the effect of range of stress *within* these limits from the experimental results is comparable to the work of the indifferent and careless student who endeavored to determine the coefficient of elasticity of a specimen by measuring the elongation under a loading which had produced a considerable permanent set.

It seems to the writer that the work of Bauschinger, the greatest and most painstaking investigator in this field, has been given but scant consideration by the average theoretical writer. For example, Bauschinger noted that the apparent elastic limits of the material under alternate compressive and tensile strains slightly beyond the primitive apparent elastic limits tended towards fixed positions somewhat greater than half of the primitive yield point, and that so far from being fatigued or brought nearer to rupture by range of stress within these limits, the specimen appeared actually improved in elasticity, tenacity and ductility, unless there were flaws. Is it altogether rational in the face of these results to provide for this improvement in quality of this material by an arbitrary reduction of the working stress? Is not, indeed, this idea leading to the use of dead-load working stresses beyond the true elastic limits of the metal? If we are to decide this question we must know what these limits are and what determines them.

THE LIMIT OF ELASTICITY.—The old idea of elastic behavior was that the elastic limit of a piece of material had not been exceeded if the material returned to its original dimensions without showing a permanent set; regard-

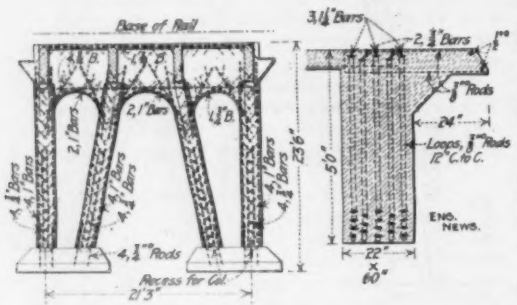

Fig. 7. Double-Track Construction, Cross-Section and Beam Detail.

less (apparently) of the question whether the material in returning to its original form could give back the same amount of energy or work which had been expended upon it, in other words, whether the energy so expended had been stored up as in a perfect spring ready to be given back as soon as the constraining forces were removed. Another definition of elasticity which has frequently been given is that the strain should be exactly proportional to the load applied. This would seem sufficiently explicit providing we had an exceedingly exact method of measuring these minute elongations. Bauschinger's work along this line has been, perhaps, the most accurate that has been done, although his results have received comparatively little consideration.

Lord Kelvin has developed the mathematical theory of the thermo-elastic properties of a perfectly elastic solid, and has demonstrated the following formulâ as applicable to the phenomena in question:

$$H = \frac{t\,p\,e}{J\,S\,W}$$

where

H = thermal increase, in degrees Centigrade
t = temperature Centigrade, from absolute zero
J = the mechanical equivalent of the thermal unit.
p = pressure applied in pounds, positive if compression and negative if tension
e = the coefficient of linear expansion
S = the specific heat of the solid and
W = the weight in pounds per foot of length of bar.

Now, as we have in the thermo-electric method

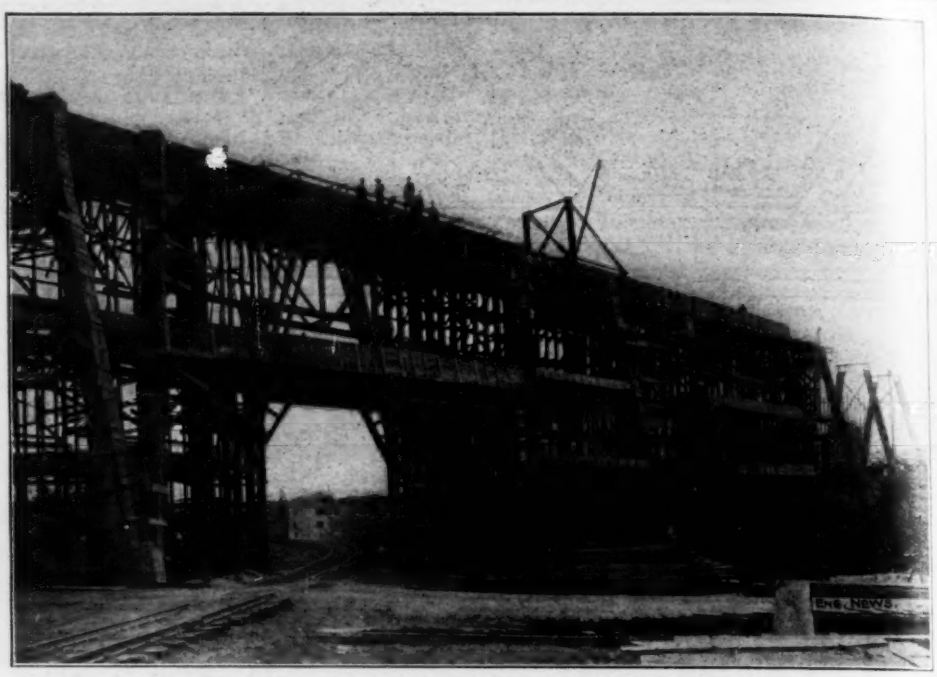

FIG. 8. FALSEWORK AND FORMING ON RICHMOND REINFORCED CONCRETE VIADUCT.

an exceedingly exact means of measuring minute temperature changes, we may readily determine the limits of loading through which the specimen follows this requirement for a perfectly elastic body. (See Trans. Am. Soc. C. E. Vol. LXVIII, Aug., 1902.) The writer's efforts along this line indicate, to his satisfaction, that this limit for good medium steel is probably in the neighborhood of 25,000 lbs. per sq. in.; that beyond this limit, it can be shown, work is done upon the material in changing its molecular structure and its position in the thermo-electric series. It should be observed that under Wöhler's treatment no sound specimen has been broken within this limit, which also appear to coincide closely with the natural elastic limits of Bauschinger.

Are we not justified in questioning whether a working stress of 24,000 lbs. per sq. in. is not encroaching altogether too closely upon this limit? Also, should we not question whether such working stresses have been commonly used by engineers where the loads actually going upon the structure reached anywhere near to the assumed loads?

IMPACT EFFECT IN WOHLER'S TESTS.—Thus far in the consideration of fatigue tests it has been supposed that the stresses applied in

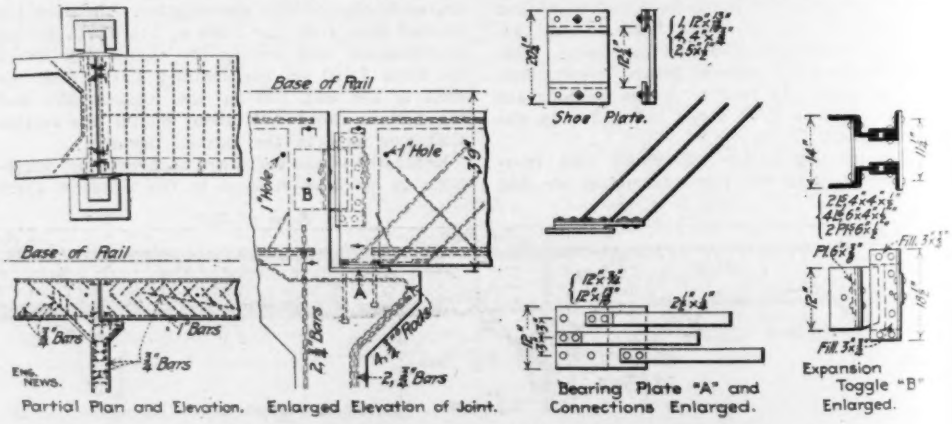

FIG. 9. EXPANSION JOINT ON CONCRETE VIADUCT.

the Wöhler experiments were really, or approximately, those which he intended they should be—limited, by the highly ingenious design of his testing apparatus, to the approximate equivalent of a gradually applied load, free from shock. It is well known that the effect of a suddenly applied load in producing deflection is greater than that due to the same load at rest, and it may be demonstrated mathematically that were the load imposed with complete suddenness, or instantaneously and without shock, its effect is to produce a momentary deflection and strain twice that of the same load at rest. Hence Mr. Fidler argues that it is permissible to doubt whether the apparatus used by Wöhler did, in fact, succeed in limiting the internal stress to the intended amount without exceeding it, and whether the bars were not subjected to the action of dynamic stresses every time the load was applied (about four times a minute). That this was the case, to a certain extent, can hardly be doubted, but the question is to be answered, if Wöhler's results are to be interpreted on this basis, what was the amount of the dynamic effect?

A careful study of the Wöhler machines would probably lead the majority of engineers to select the one for repeated bending in opposite directions, as the one most likely to cause the maximum dynamic stresses; and perhaps the maximum estimate of this effect, in view of the slow speed of the machine (four revolutions per minute), would be less than 20 to 30% of the load on the cantilever end of the specimen. Mr. Fidler's estimate, however, would be six to ten times as great, being reached by considering it possible that elastic vibrations induced in the specimen might bring the internal stress up to the maximum effect of a suddenly applied load (which in this case would be three times the load, since the range of stress is twice the load). The following is his table for the minimum breaking load, a, by the dynamic theory:

Steady load, no variation, $a = t$ = ultimate strength, static test.

Load varying from 0 to u, $a = u = \frac{1}{2}\,t$.

Load varying from $-v$ to $+v$, $a = v = \frac{1}{3}t$.

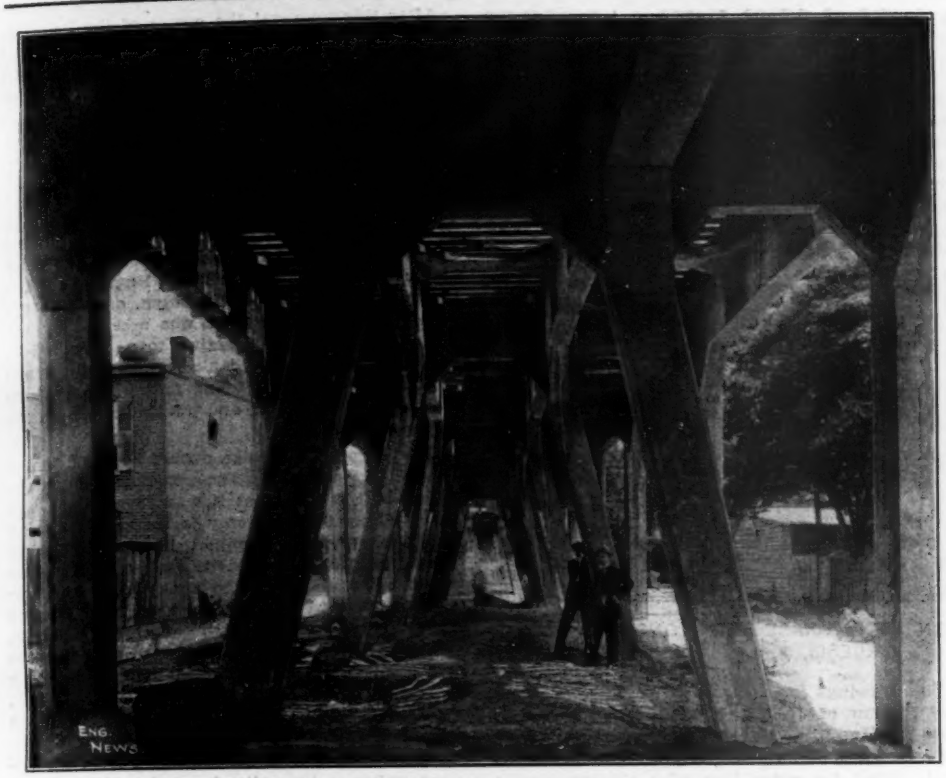

FIG. 10. VIEW SHOWING TRANSVERSE CONSTRUCTION OF VIADUCT.

If we subject a bar to a suddenly applied load, the external work of the load is its weight times the deformation of the bar, which must be balanced by the internal work, which is the product of the mean stress times the elastic deformation. Hence the deflection or deformation for the suddenly applied load will be twice that caused by the same load at rest, since the mean internal stress is only half the maximum. If, however, this dynamic stress exceeds the yield point, part of the internal work will be performed in plastic deformation, resulting in raising the yield point, just as with a steadily applied load. Hence, in ductile material, a suddenly applied load greater than half the ultimate strength would not produce immediate rupture, but would have to be applied a number of times before producing rupture, and on this basis Mr. Fidler undertakes to account for the endurance of specimens in the Wöhler experiments where the dynamic stresses (if figured on his proposed basis) would be considerably greater than the nominal strength of the material.

Now, the yield-point in mild steel is approximately 60% of the ultimate strength. If then we limit the range (plus and minus) of the alternate stresses in the Wöhler machine to something less than one-third of the ultimate strength, the endurance of the piece seems practically indefinite, and the yield-point has not been raised, as no plastic deformation occurs, although the dynamic stresses by Mr. Fidler's method of computation have exceeded the yield-point by between 40 and 50 %. Since the conditions of application of the load have been the same for the lower and the higher intensities of stress, the same line of reasoning advanced to support the probable accuracy of the dynamic theory may be used with far better advantage to prove its improbability.

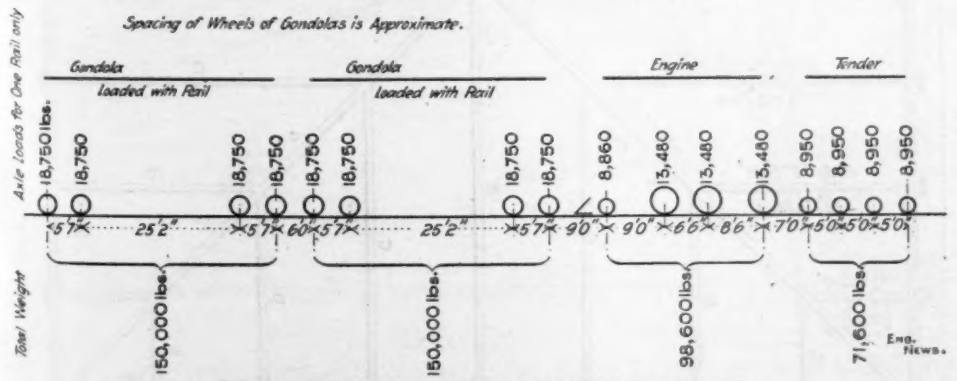

FIG. 11. TEST LOAD USED ON RICHMOND VIADUCT.

It has been argued that in a short test-piece, under direct stress, the amplitude of the elastic vibrations under the dynamic stresses would be so small as to escape observation. This argument would have indeed some weight where the stresses are direct and the test-piece short, but as similar fatigue occurs under bending, the argument would seem to be invalid, since in the bending-specimen the vibrations would have so considerable an amplitude as to render their detection certain if these stresses were of anything like the magnitude supposed.

But the greatest difficulty of the hypothesis of high dynamic effect in Wöhler's experiments is this: The dynamic increase of deformation and stress is due entirely to the velocity acquired by the load in causing the deflection. The 100% increase for stress of one kind, or 200% for alternating stress, occurs only when the deflection is unrestrained and therefore practically instantaneous. When the time which it takes to apply the load is as great as 15 sec., or 7½ sec., as in Wöhler's test, the velocity effect is reduced to a vanishingly small amount. The existence of dynamic increase of stress can therefore hardly be possible. In fact it would appear that this final absurdity has caused not a few engineers to discard the hypothesis, in framing their later specifications, and to make an allowance for the dynamic effect of loads on the more rational basis of considering, (1) the length of span, or that portion of it which, when loaded, causes the maximum stress in the member, and (2) the character of the traffic, or the loading to which the structure is subjected.

It should be noted that Mr. Cooper's specification is based on the dynamic theory of Mr. Fidler, which Mr. Schneider discards.

THE YIELD-POINT AS ULTIMATE LIMIT.—As applied to a framed structure, the idea that the ultimate strength of the metal in the frame is a radically different proposition from the ultimate strength of a specimen in the testing machine, may be correctly credited to Messrs. Fowler and Baker, since they apparently appreciated the fact that after the metal in a frame commences to stretch in the tension members and flow in compression members, the form of the frame and of the diagram upon which we base our computation of stress is destroyed, while the dynamic effect of the falling mass limits the idea of the ultimate strength of a framed structure closely to the yield-point value of the metal in its members. This being the case, what excuse can be offered for such a working stress, as

$$p = 12{,}000\left(1 + \frac{\text{min. stress}}{\text{max. stress}}\right)$$

for range of stress of one kind only?

In view of the fact that the yield-point value is the practical ultimate strength of all members with reference to the frame as a whole, and also the ultimate strength of all members under indefinite repetitions of stress of one kind only, are we not endeavoring to introduce the conception of imaginary values of the ultimate strength in employing such formulas, and producing a frame with each and every part of variable strength, and with a variable instead of a uniform factor of safety for practical working conditions?

To the student of even elementary physics it should be apparent that the fatigue in an endurance test is a molecular phenomenon, governed by the same general laws as account for the elastic after-working in an overstrained material in which the element of time largely affects the result; or the temporary fatigue of elasticity in specimens subject to torsional vibration, where, according to Tomlinson, elastic fatigue appears to depend upon the immediately previous molecular condition (whether of quiescence or recurring changes of shape), and is found entirely wanting where the vibrations are kept within well defined limits. The idea that a correct estimate of its characteristics may be arrived at by such a simple exhibit of algebraic gymnastics as presented in the derivation of these fatigue formulas, which carefully exclude the main elements upon which the phenomenon depends, is no less surprising than the abnormal proportions and lack of safety in structural designs made with the employment of such methods.

That doubts have evidently occurred to the advocates of fatigue formulas as to the propriety of applying a large factor of ignorance to the results of fatigue tests in arriving at their so-called rational working stresses is clear from consideration of the arguments advanced in support of their position. In "Materials of Construction," p. 547, J. B. Johnson says, "Another argument in favor of this (fatigue) formula lies in the fact that it is the same as the old rule of using twice the factor of safety for live as for dead load," as he proves by algebraic equations. The fact that some empirical fatigue formula can be correctly shown equivalent to Fidler's dynamic absurdity, would seem to strengthen neither, since two illogical solutions of a problem, although starting from different standpoints and arriving at equivalent results are not a safe substitute for a logical solution when life depends thereon.

It should be noted that although Mr. Cooper uses the old rule or Fidler's basis in specifying his working stresses, his practical judgment is not fully satisfied with these relations, and for that reason he has juggled the working stresses

of chords and posts in an arbitrary manner which appeals to him as the better suited to meet the practical requirements of design.

The writer desires to make his position in the foregoing criticism better understood by the frank statement that, with but one exception, in every piece of bridge work with which he has been connected as consulting engineer he has specified the general requirements of Mr. Cooper's specifications to govern the details of construction, although modifying the unit-stresses as his judgment deemed best. This fact represents his estimate of the value of Cooper's work.

DETERMINATION OF WORKING STRESSES.—Starting then on the basis of the writer's view of a definite and fixed limit of elasticity (after the material has been subjected to a sufficient range of stress or moderate temperature changes to relieve unequal conditions of internal stress due to previous treatment), what are the governing conditions in deciding upon the permissible working stresses? As the writer would look at it, the first condition that should be taken into consideration would be the probability of perfect workmanship in bringing the load upon the member uniformly over the various parts of the section. In other words, entering into this question would be the accuracy with which, for example, eye bars may be bored to exact length, and thus enable them to work together in the chain. This has been pretty well discussed in papers dealing with the subject relative to the Quebec design.

We should also take into consideration the accuracy with which the frame is lined up. Perhaps an allowance of 20% for the possible inaccuracies in this would be none too large. Then, for variations in quality of the material, make-up of built members, etc., from 15 to 20% more might be allowed. This would leave us from 16,000 to 17,000 lbs. per sq. in., which is the writer's idea of a fair working stress. The dynamic effect of rolling loads should, of course, be considered additionally.

Owing to the fact that compression formulas give no data as regards the fiber-stress in columns, we must needs allow an extra margin of safety in members subject to alternate tensile and compressive strains, until we shall have developed our column formulas so that we know what the actual fiber-stress is, since Wöhler's work shows beyond question the rapid injury resulting from alternation of tensile and compressive stress to minus, when it exceeds well defined limits. Such an allowance, however, if the writer's position be correct, should be based more rationally on length of the column and the amount of compression involved, rather than upon the total of compression and tension as is usually done.

WORKING STRESSES FOR DETAILS.—In the matter of details and allowance for rivets, there seems to be an even greater variation than in the specification for working stresses on main members. The writer would recommend as conservative, unit values at least 10% lower for shear and 20% lower for bearing than those adopted by Mr. Schneider. In deciding upon the working stresses for a heavy frame, it would seem, too, that we could expect more accurate shop work than would generally be done upon lighter members, and perhaps a small allowance in favor of the heavier frame would be along the line of legitimate economy.

The subject which the writer has endeavored to discuss in these few lines is a broad one, indeed, and most difficult to handle perfectly, and a general discussion of the points raised may materially aid the profession in coming to more uniform conclusions on this important subject.

A LIGHT ROOF GIRDER SYSTEM IN A REINFORCED CONCRETE GARAGE.

Some weeks ago our attention was called to a reinforced concrete automobile garage at Sea Gate, Coney Island, in New York City, which had developed some threatening cracks in a roof system containing girders of very bold design. The structure was carefully examined by members of the editorial staff of this journal and an investigation was made of its history, which was found to be as follows:

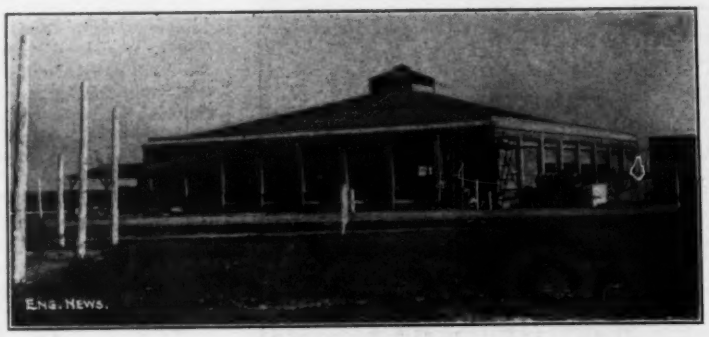

FIG. 1. REINFORCED-CONCRETE GARAGE WITH LONG-SPAN ROOF GIRDERS.

The drawings for the garage were presented to the Bureau of Buildings of Brooklyn early in 1906 by Mr. J. A. Macdonald, the architect who was responsible for the design. The plans, as filed, called for a building with similar outside concrete walls to those shown in Fig. 2, with pilasters along two parallel sides, spaced every 12 ft. 6½ ins., supporting light steel roof trusses 14 ft. high, which in turn carried a tile roof. In these plans the walls were not reinforced, but the department afterward called for steel reinforcement. With a few minor changes this design was approved by the Department of Buildings.

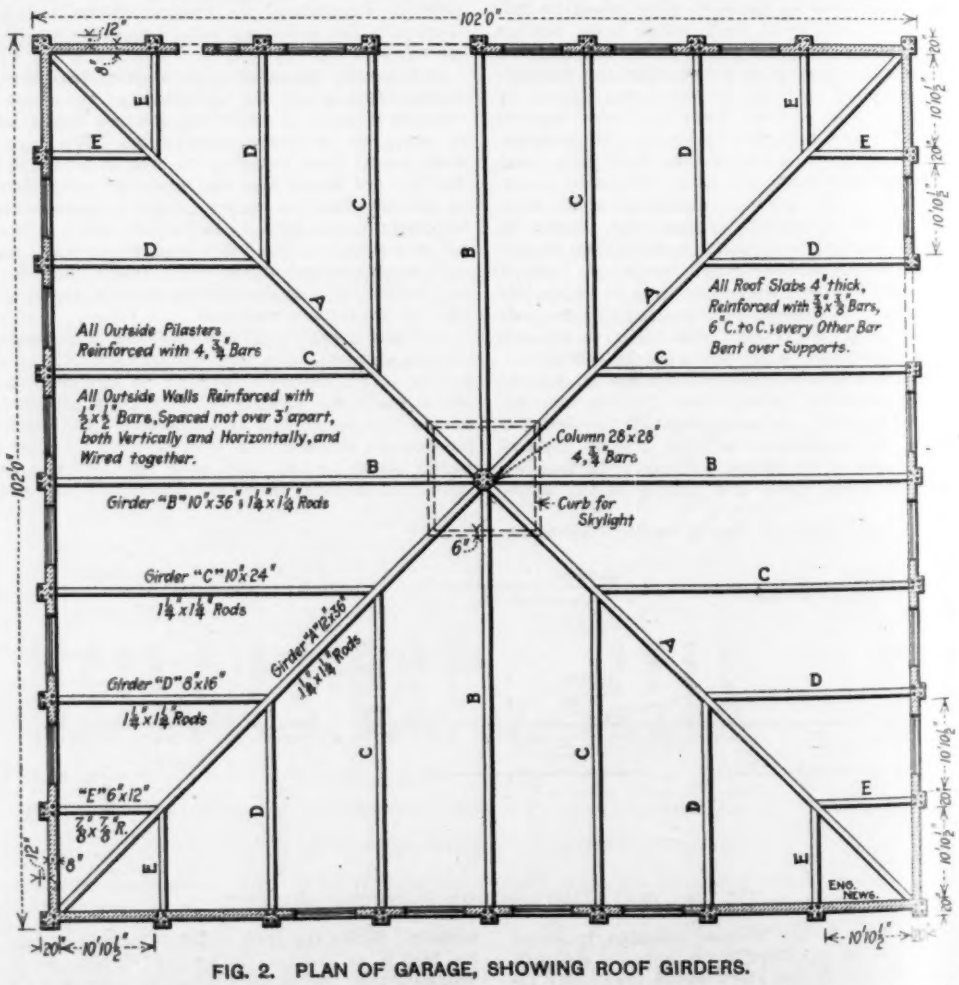
102'0"
All Outside Pilasters Reinforced with 4, ¾" Bars
All Outside Walls Reinforced with ½"x½" Bars, Spaced not over 3' apart, both Vertically and Horizontally, and Wired together.
All Roof Slabs 4" thick, Reinforced with ⅜"x⅜" Bars, 6" C. to C. every Other Bar Bent over Supports.
Column 28"x28" 4, ¾" Bars
Curb for Skylight
Girder "B" 10"x36" 1¼"x1¼" Rods
Girder "C" 10"x24" 1¼"x1¼" Rods
Girder "A" 12"x36" 1¼"x1¼" Rods
Girder "D" 8"x16" 1¼"x1¼" Rods
"E" 6"x12" ⅞"x⅞" R.
ENG. NEWS.

FIG. 2. PLAN OF GARAGE, SHOWING ROOF GIRDERS.

After this approval the owner of the building, becoming impressed apparently with the merits of concrete as a building material, asked the architect to change the steel roof trusses to concrete girders spanning from wall to wall. The architect objected to this on account of the great depth of girder necessary for a 102-ft. span and the consequent reduction in head room. He submitted to the Building Department several designs, however, none of which was approved. Noting that the architect seemed unable to present a design in conformity with the rules of the city, Mr. P. A. Faribault, Engineer for the Bureau of Buildings, of Brooklyn, offered to design the roof, which offer was accepted by the owner. While also objecting to a clear 102-ft. span system, Mr. Faribault furnished the plans shown in the accompanying figures, from which the garage was erected and put into service in the summer of 1906.

This revised roof design cannot be found in the records of the Building Department, although the department admits that it was passed upon and approved by it. Not only is the revised design missing, a fact that might be due to clerical carelessness incident to the moving of the records from one building to another, but the records for the old design of a steel truss contain no reference whatsoever to the changed details, although it is a rule of the office to record on the first paper all changes made before or during construction. As far as the official records show, a steel roof truss was built on concrete walls in this garage.

The new design, it will be noted from the accompanying cuts, calls for a square building 102 ft. on a side, divided on each side into eight panels by reinforced-concrete pilasters connected by 8-in. walls. In the center of the square rises an octagonal concrete column, 28 ins. in diameter and 28 ft. high, from the top of which eight girders descend to the corners and sides of the walls. Intermediate beams connect the diagonal girders to the pilasters. The roof consists of a 4-in. concrete slab covered with tile. The

four corner girders are about 74.1 ft. long, or 72.1 ft. in plan, and are 12 x 36 ins. in section, reinforced at the bottom by nine 1¼-in. rods, in two rows; the four other large girders are 51 ft. in plan and 10 x 36 ins. in section, reinforced with five 1¼-in. rods in two rows. A portion of all of the tension rods are bent up to the upper side of the beam at supports. The smaller girders grade down in size toward the corners. The center column is octagonal in shape and reinforced with four ¾-in. rods, distributed around the circumference. These details and others are all on the drawing which we have reproduced; they are noted here to call attention to the small dimensions compared with those usually employed in similar work. The walls and center column are all founded on spread footings reaching 4 ft. below the surface to a good sand foundation.

For the first six months the building showed no signs of failure, but after that time cracks began to appear at various places about the roof system. Most of these cracks occurred around the southwest diagonal long span girder, as is well shown in Fig. 5. Here it will be seen that the main girder has left the roof slab for a space of at least 2 ins. at the middle, diminishing to nothing at the end, carrying with it the smaller girders. A pronounced shear crack has also appeared in this large girder about 6 ins. from its support at the column. Besides this girder, one other large girder shows small cracks similar to those in the half-tone but not over as great an area. The entire line of connection between the roof and the west wall has opened, and a similar crack has started in the north wall immediately over the entrance to the garage. Throughout the structure evidences of incipient cracking are apparent.

The outside corner pilaster upon which rests the diagonal girder which has developed the largest cracks, has left the cornice and side walls, showing a crack of about an inch. Whether this is due to a settlement at the base of the pilaster or to the deflection of the girder is uncertain. The footings here are good hard sand, but it is claimed by the contractor that pools of water were struck in the excavation and that the foundations were liable to settle a bit if this water were drained off. However, the cracks in the girder seem to be characteristic of deflection due to load and not to sinking at one end.

Efforts have been made to remedy the cracking by filling up all openings, as they have appeared, with concrete mortar. This has been done under the assumption that the openings between the beams and the roof slab were due to a settlement of the pilaster and that no deflection has occurred in the beam.

Such was the condition of the building when brought to our attention. In order to get an impartial opinion upon the construction, we forwarded the plans to Mr. Rudolph P. Miller, M. Am. Soc. C. E., Consulting Engineer, and late Chief Engineer of the Bureau of Buildings, Borough of Manhattan. Removing from the drawings all evidence of the location of the building

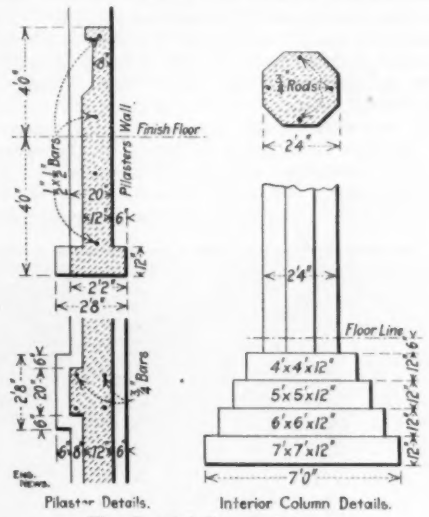

Fig. 3. Details of Columns.

or the identity of its designing engineer, we asked for a report on such a design under the regulations of the New York Building Department. Mr. Miller's report is as follows:

Sir: In accordance with your request, I beg to submit herewith the results of an examination into the strength of a reinforced-concrete structure as indicated by the three plans which you sent me.

I understand that this structure was supposed to be designed in accordance with the regulations of New York City governing reinforced-concrete construction. This means that the calculations for strength are to be made under the right line theory of distribution of stress, that the ratio of moduli of elasticity of steel to concrete is 12, that the concrete takes no tension, that the beams or girders must be considered as supported at the ends only and that a part of the roof plates can be taken as part of the girder.

The weight of the concrete with its reinforcement is assumed to be 144 lbs. per cu. ft. and, as the slope of the roof is less than 20° with the horizontal plane, the live load is taken at 50 lbs. per sq. ft. of roof area, measured on a horizontal plane. No roofing is shown on the drawings and no allowance has been made for any in the calculations.

If any attempt was made in the design to conform with the requirements of the New York regulations as to unit stresses, the live load must have been neglected and insufficient allowance made for the weight of the construction in the consideration of the beams and girders, or it is possible that live load was considered but that insufficient allowance was made for weight of the construction. At any rate, all parts of the construction are weak, if live load is considered and most parts are weak even when the weight of construction alone is considered.

In the roof slab the concrete is stressed to 800 lbs. per sq. in. in the extreme fiber, and the steel is stressed to 20,400 lbs. per sq. in. If the live load is neglected, the stresses would be about one-half, or about 445 lbs. and 10,000 lbs. per sq. in. respectively. These stresses are determined on the assumption that the reinforcement is continuous over supports, which it is apparently intended to be, judging from the note on the "Floor Plan"—"every other bar bent over supports." The position of the steel bars in the roof slab is not given on the drawings, but it was assumed to be ¾-in. above the lower surface of the slab, at a point midway between supports, and it is assumed that at least half of the rods incline toward the upper surface as they approach the supports. The maximum bending moment in the slab was taken at $\frac{W\,l}{10}$. This is in accordance with New York practice, although some authorities sanction the use of $\frac{W\,l}{12}$. Under the latter assumption the stresses due to live and dead loads would equal about 740 lbs. for the concrete and about 17,000 for the steel.

Some authorities consider 750 lbs. as a safe value for the working stress in the extreme fiber of concrete in compression. The New York regulations fix this value at 500. The safe working stress of high carbon steel in tension is often taken at 20,000 lbs. per sq. in., though the New York regulations allow only 16,000 lbs. per sq. in. in any case.

Under New York practice, therefore, the slab would be due to live and dead loads equal to about 740 lbs. for the concrete and about 17,000 for the steel.

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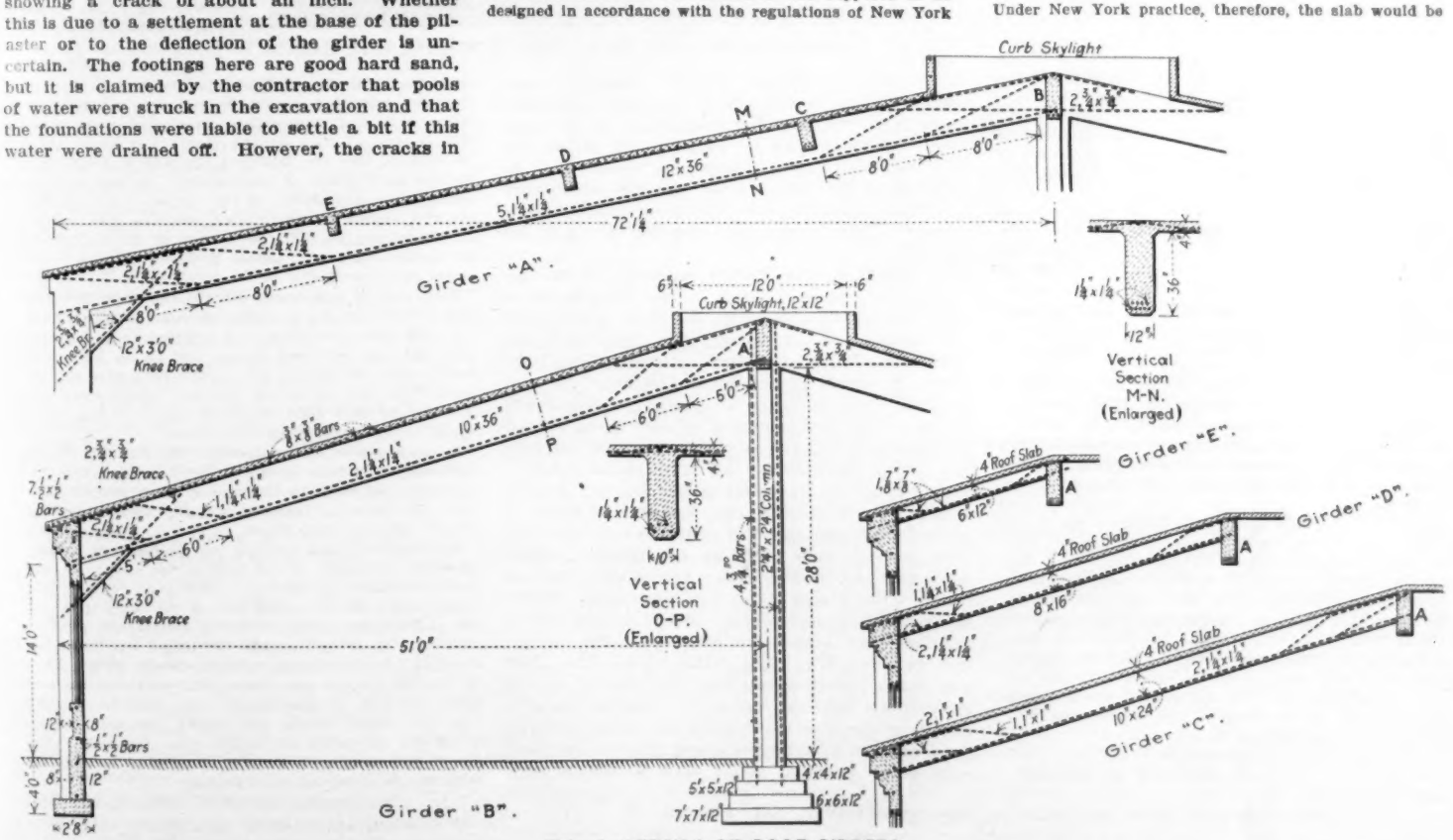

FIG. 4. DETAILS OF ROOF GIRDERS.

In girders "B," "C," "D" and "E," the extreme fiber stress in the concrete does not exceed 500 lbs. for entire live and dead loads. The stress in the steel is less than 16,000 lbs. per sq. in. in girders "D" and "E." In girders "B" and "C" it is in excess of 16,000 lbs., but less than 20,000 lbs.

No provision for web reinforcement has been made in any of these girders, other than turning up part of the tension rods at the quarter points. In all of these girders the horizontal shearing stress at the quarter points is in excess of 50 lbs. or that allowed by the New York Regulations (that is, those in effect in Manhattan). In Brooklyn a somewhat higher stress is allowed, namely: 75 lbs. But even that stress is exceeded in these girders. The stress, however, is still within 100 lbs. per sq. in., a value now accepted as safe by many authorities.

While I believe that stirrups should be provided in all these girders, it may still be said that, under the more liberal assumptions prevailing outside of New York, these girders are safe, if high carbon steel has been used.

When we come to the hip rafters, however, the most liberal assumptions and practice cannot bring these members within the pale of good or safe construction. In the first place, the question arises as to how much, if any, of the roof slab may be considered as part of the compression flange of the girder. Unquestionably this slab does materially add to the strength of the girder, even though the flange formed by it slopes outwardly toward the neutral axis. If, for the purposes of this examination, the flange is considered as at right angles with the stem of the girder (thus securing a better result than is perhaps justified), the concrete is stressed to 1,100 lbs. per sq. in. and the steel to 27,800 lbs. per sq. in., under the combined live and dead loads. Neglecting the live load, the stresses become 720 lbs. for the concrete and 18,200 lbs. for the steel, both of which are, in my opinion, too high, because of the unjustified assumption as to the flange.

In this girder, too, no shear reinforcement has been provided other than turning up the tension rods. The horizontal shear at the quarter point is 115 lbs. per sq. in. The New York requirements allow 50; the most liberal authorities suggest 100 lbs. as safe. I would consider the hip rafters, marked "Girder A," unsafe.

The wall columns are all well within the limits of safety, the stress on the concrete being in all cases within 200 lbs. per sq. in.

The central column carries 435,000 lbs., which is about 30% of the entire roof load, including the live load. This is a load of 607 lbs. per sq in. on the gross area of the column.

The column in question has a ratio of length to diameter of 12 and the reinforcement is about 0.4%. Tests show that for such a column the breaking load will be under 2,000 lbs. per sq. in., allowing in this case, therefore, a factor of safety of less than three. It is fair to presume that the concrete used in the column was not better, if as good, than that of the test columns.

Even if we take the best results shown by tests, for sake of comparison, there would be a factor of safety of only 3.6. This for concrete construction is too small. I would therefore, consider the central column inadequate, if not unsafe.

Under the New York regulations, the strength of a column is taken as the product of the allowable unit load on the concrete (350 lbs. per sq. in.) times the sum of the sectional area of the concrete and twelve times the sectional area of steel. Figuring out the unit stresses in the column in question, on this basis, the concrete is loaded to 648 lbs. per sq. in. and the steel to 7,776 lbs. per sq. in. The concrete is stressed to nearly double the allowable stress.

In Brooklyn a load of 600 lbs. per sq. in. is permitted on the gross sectional area of concrete. Even under this provision the concrete is overstressed.

The footing under the central column is certainly safe. But the unit load on the soil under this footing (4.6 tons per sq. ft.) is very much greater than that under the wall columns.

Considering the building, in its entirety, I am of the opinion that, if the materials are in accordance with New York requirements, it will probably stand and serve its purpose, though it is without question badly designed and not in accordance with legal requirements.

The Brooklyn regulations are the same in most requirements as those in use in Manhattan but differ from them in some important particulars, among which are the following: Allowable shear stress in concrete 75 lbs. per sq. in. In columns, in which the vertical reinforcement is at least 1/200 of the concrete, the working load may be taken at 600 lbs. per sq. in.

Respectfully,
RUDOLPH P. MILLER.

The stresses computed by Mr. Miller are summarized in the table below.

So much for the design of the structure. Turning now to the construction, we have been able to learn comparatively little concerning it. An inspection of the building as it now stands reveals nothing regarding the materials or methods of construction other than can be deduced from the presence of the aforementioned cracks. The placing of rods, contents of mixture, and other interior details upon which stability depends, must be matters of evidence by parties directly interested. Our information is that the owner, upon having the design accepted, let the contract for concrete construction to Mr. F. P. Gallagher, a local contractor who had had experience in concrete work, although probably never on so large a scale. The architect and engineer concerned with the design had no connection whatever with the construction; the owner assumed entire responsibility for inspection of the contractor's work. As is usual in all cities, the building department inspectors could not do more than exercise a most general supervisory inspection over the work; the finer details had to be left to the contractors and the owner or his agents.

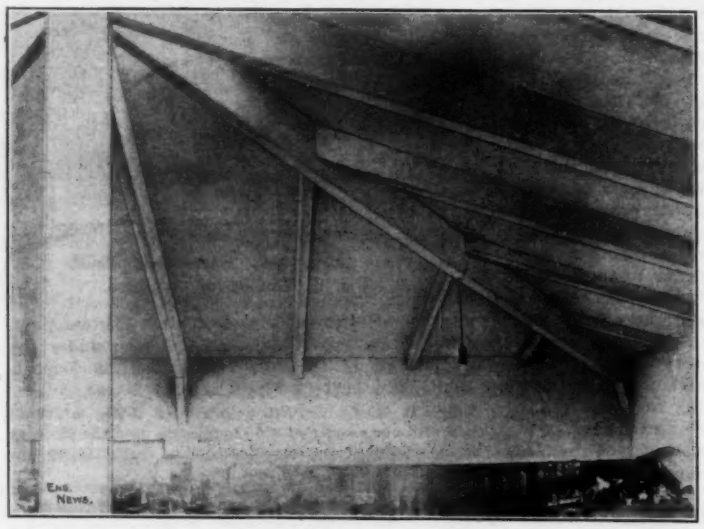

FIG. 5. CRACKS IN ROOF GIRDERS OF SEA GATE CONCRETE GARAGE.

The building was erected according to the design, except for one detail. After the side walls were completed some fears for their safety were entertained and it was decided to place 1½-in. tie rods along the face of each wall extending from corner to corner just under the eaves of the roof and to concrete them in place by superposed molds. This was done and to date these affixed tie rods seem to have an integral connection with the rest of the building. A 1:2:5 machine-mixed gravel concrete was used (note that 1:2:4 mixture is New York rule), the character of which is a matter of opinion. The contractor claims that this concrete was quite up to standard, made according to prescribed rules out of the best material, with all possible care as to placing. There is, however, considerable evidence of work of a different sort. From one observer, quite competent to judge, it is learned that at one time lime was being partly substituted for cement in the mixture for the side walls. An examination of a sample of concrete taken from the girder showing the worst crack, indicates a very inferior mixture, with stone pockets, voids, cinders and a very fine black sand. In spite of this damaging evidence against the concrete, the fact that it has up to date resisted the high stresses given in Mr. Miller's report would indicate that it cannot be of very poor quality.

The walls were laid as monoliths with forms to represent coursing on the outside. Each beam was cast by itself with the roof slab cast afterward as a separate member. Thus the T-beam action assumed by Mr. Miller will not hold and the theoretical stresses for the beams, as shown in his report, are low. According to the best information the forms were left up a sufficient length of time, although the designing engineer gives their premature removal as one of the causes of cracking. The only testimony available regarding the sizes and position of the rods comes from the contractor, who says that they were placed in exact accordance with the plans, which, it will be noticed, are somewhat vague in this respect.

The statements noted above, as to design and construction, have been referred to the engineer who designed the roof—Mr. Faribault—for verification. He has furnished us with a statement, the substance of which is as follows:

Original plans submitted to this Bureau called for steel roof trusses. Upon examination I found that these were not properly designed and too light. The plans, however, were approved so as to allow the owner to proceed with the erection of the walls, with the understanding that plans would be submitted later on showing proper roof construction. Then the owner decided to build the roof of reinforced concrete. His architect submitted several designs, but not being familiar with this construction, none were acceptable to this Bureau. I then decided that I had better design the roof for him, and furnished him with a sketch showing the main details of construction. As near as I can recollect, an amendment to the original plans, showing the new method of construction, was filed with and approved by this Bureau. No records of the changes can be found, but I am almost positive that the proper amendment was filed.

Roof girders and beams were designed as T-beams, and general design complied with rules of this Bureau.

At the time I instructed the architect to be sure and have the roof slabs and girders laid at the same time, and to have all stirrups run up and hook over the slab bars. The line of failure, however, would show that this has not been done; otherwise cracks, if any, would appear in the slabs along the girders.

As each one of our inspectors has from 75 to 100 buildings under way to look after, it is a physical impossibility for them to give any of them proper attention. We have no inspector specially detailed to reinforced concrete construction.

The causes of the cracking are probably as follows: Lack of experience on the part of the contractor, and lack of supervision generally give poor results. The beams and slabs not being cast at the same time, and the stirrups not being carried up and hooked over the slab bars, as intended, made the beams free beams instead of T-beams. Concrete placed into the girders forms in freezing weather and shores removed before the concrete had time to properly set; our inspector tells me that the girder which now shows the most serious crack did sag when the shores were removed. The use of fine sand, cinders carelessly allowed to be mixed with the concrete and poor mixing.

The photographs herewith reproduced were taken about eight weeks ago, before the cracks had been filled up with mortar. Fig. 1 is a view of the building looking toward the corner pilaster in which settlement is supposed to have occurred. A close inspection will reveal a sag in the roof between each visible corner hip and the middle supporting girder. Whether this sag is in the roof slabs or merely in the tile covering, it is impossible to state. A similar unevenness is noticeable on each side.

We have commented on the building on our editorial pages.

TABLE SHOWING UNIT STRESSES IN GARAGE MEMBERS, LBS. PER SQ. IN.

Members.	Concrete. Dead load. Compression.	Concrete. Total load. Shear.	Concrete. Total load. Compression.	Steel. Dead load. Tension.	Steel. Total load. Tension.
Floor slab:					
$M = Wl \div 10$	445	.....	890	10,000	20,400
$M = Wl \div 12$	....	.....	740	.....	17,000
Small girders...	....	75 — 100	< 500	.....	16,000 — 20,000
Large girders*..	720	115	1,100	18,200	27,800
Wall columns...	....	.....	< 200	.....	.....
Center columns.	....	.....	607	.....	.....

*T-beam assumption.

NEW YORK BUILDING REGULATIONS.

	Manhattan.	Brooklyn.
Extreme fiber stress on concrete in comp.	500	500
Shearing stress in concrete	50	75
Concrete in direct compression	350	600
Tensile stress in steel	16,000	16,000

THE DESIGN OF 75-FT. REINFORCED-CONCRETE GIRDERS FOR THE MAMMOTH GARAGE, WHITE PLAINS, N. Y.

By C. E. TIRRELL.*

The Mammoth Garage at White Plains, N. Y., is a reinforced-concrete building 77 ft. wide and about 260 ft. long. The front portion of the building, containing the offices, supply rooms and reception rooms, is of two stories. The rear of the building is devoted to a machine and repair shop, vulcanizing room, oil room, tool room, and wash rooms. This is of one story construction, and although there are no skylights in the roof, the windows which fill the entire wall space between the columns on three sides are carried up to the under side of the wall beams, thus producing an exceptionally well lighted shop. The central portion of the building, also of one story, is intended for the storage and care of automobiles. For this purpose the owners desired to have a room about 120 ft. long and the full width between walls, unobstructed by columns. It was necessary, therefore, to use girders 75 ft. in span, and as it was thought undesirable to reduce the fire-resistance of the building by making them of steel, they were also built of reinforced concrete, though the span is an unusual one for this material.

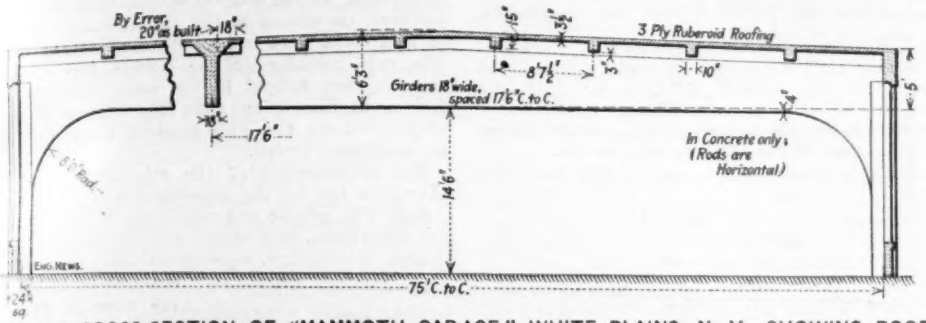

FIG. 1. CROSS-SECTION OF "MAMMOTH GARAGE," WHITE PLAINS, N. Y., SHOWING ROOF CONSTRUCTION WITH 75-FT. REINFORCED CONCRETE GIRDERS.

The general design of this long-span roof is shown in Fig. 1, which represents a cross-section through the middle portion of the building. The long girders are spaced 17 ft. 6 ins. apart. They carry a beam-and-slab roof construction, comprising a 3½-in. slab spanning 8 ft. 7½ ins. between centers of beams, and 10 × 15-in. beams extending between the main girders. The whole construction is designed for a live-load of 30 lbs. per sq. ft. Ruberoid roofing covers the slab.

While reinforced-concrete girders of greater length have been built, and spans nearly as long as this are becoming more and more common, there is so little information available regarding them which is of real value to designers to assist in the development of safe and economical designs, that it seems best to describe in this article the most important points which arose in the design of these girders.

In speaking of economy it is not intended to convey the idea that spans of this size can be built to compare in cost with a construction making use of intermediate columns. The purpose of the article is, rather, to describe the method by which long-span concrete girders may be designed in strict observance of the laws of conservative engineering practice, with the aim of producing a thoroughly safe and serviceable structure at minimum cost.

GENERAL CONDITIONS. — Although these girders are reinforced at the ends in such a way that a part of the bending moment will most certainly be taken up by the columns, they were figured as if simply supported at the ends, to cover the possibility of a lateral movement of the footings.

In a girder of this size it was conceived that there might be a settlement of the concrete during the process of setting and hardening, sufficient to destroy the bond between the girder and the slab. If this should occur it would not be possible to utilize the slab or even any portion of it in compression. Moreover, even should there be a perfect bond between the two, the fact that the slab spans from beam to beam in the same direction as the length of the girder leads us to suppose that there would be caused in the slab a compressive stress in addition to that in the top of the slab due to its own flexure. In reality, reinforcement was placed over the top of the girder for the purpose of bonding the slab to it, and to bring some of the slab load directly to the girder without being transmitted through the beams. But in view of the fact that the girders are exposed to the extremes of temperature, even this precaution was not considered sufficient to warrant using any of the slab in compression. Therefore, in order to get the necessary compression area in concrete economically, large 45° fillets were placed at the junction of the girder and the slab, enlarging the compression area of the girder cross-section effectively.

Preliminary computations showed that a girder built under these conditions on a basis of a maximum allowable compressive stress in the concrete of 500 lbs. per sq. in. would be excessively heavy, and probably not as economical as one built of a concrete somewhat richer in cement than is ordinarily used, upon which a higher unit compressive stress could be used with as great safety as with the leaner concrete and lower compressive stress. It was therefore decided that the concrete for these girders and for the entire roof on this part of the building should be of such quality as would provide an ample factor of safety for a maximum compressive stress of 750 lbs. per sq. in. when the falsework is removed at the end of six weeks. A 1:1½:3 mixture was used, the stone being New Haven trap, and the sand a well graded bank-sand of excellent quality. The intention was to provide a concrete having an ultimate crushing strength of not less than 3,000 lbs. per sq. in. at thirty days.

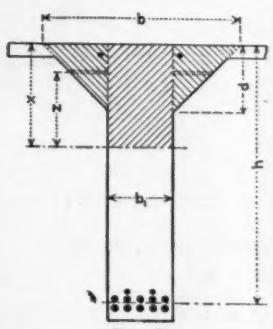

Fig. 2.

The size of these girders was determined after successive trials, the object being to reduce their size and weight to a minimum without overstepping the allowable unit-stresses for compression, tension, and shear. The filleted section required a modified method of calculation for the design, which method is given below in detail. The dimensions of the girders having been chosen from the preliminary approximations, the final computations were made according to this method.

The girders are 18 ins. wide, 6 ft. 3 ins. deep over the concrete at midspan, and 5 ft. deep at the ends (except for 4 ins. of camber in the bottom face, which makes the actual end depth 64 ins.; the rods, however, run horizontally). The fillets are 18 ins. deep from the top of the slab, the latter being 3½ ins. thick. At mid-span the distance from the center of the steel to the top of the slab is 70 ins.

The modulus of elasticity of the concrete in compression was assumed to be constant within the working limits, at 2,000,000 lbs. per sq. in., thus giving the so-called straight line distribution of stress.

The choice of the ratio of moduli of the steel and concrete was made after due consideration of the nature of the concrete and the effect of aging. The girder was figured for its full live-load at the age of six weeks. This comparatively green concrete would at that age probably have a modulus of but little more than 2,000,000 lbs. per sq. in. As the hardening process continues, the modulus increases. Now, considering the case of no concrete below the neutral axis, such increase in the modulus as the concrete hardens would result in a rise in the position of the neutral axis and a decrease in the area of concrete in compression, thus causing a higher maximum compressive stress in the concrete than was originally intended.

However, there must be a considerable amount of tension in the concrete below the neutral axis, and although its intensity and manner of distribution are highly problematical, there is no doubt that its effect can be counted upon with assurance as lending additional strength to the girder. The effect of this tensile stress in the concrete would be to offset in some degree the effect which the aging of the concrete had in raising the position of the neutral axis; and, indeed, it is entirely probable that in this particular case the neutral axis at the end of a few months will be somewhat below the point at which it was assumed.

CALCULATION FOR FLEXURE.—Referring to the diagram Fig. 2 of the section of the girder, the following are the symbols used in the development of the theory:

b_1 = width of stem of girder.
h = depth to center of steel.
b = width across top of fillets or wings.
d = depth of fillets.
x = distance of neutral axis from top of girder.
c = maximum compressive stress in concrete at the extreme fiber = 750 lbs. per sq. in.
f = maximum tensile stress in the steel in tension = 16,000 lbs. per sq. in.
m = ratio between the moduli of elasticity of steel and concrete = 15.

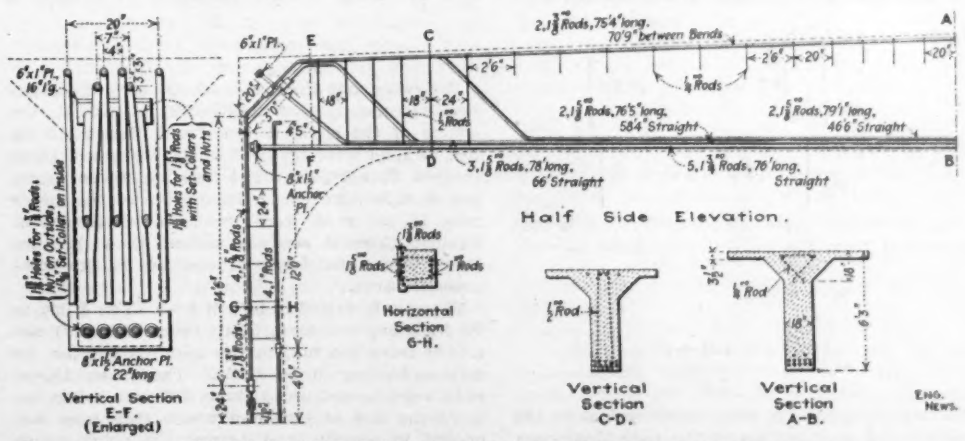

FIG. 3. REINFORCEMENT DETAILS, 75-FT. REINFORCED CONCRETE GIRDERS.

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c' = unit compressive stress in the concrete at any point between the neutral axis and the top of the girder.
a_s = area of steel in bottom of girder.
a'_s = area of steel in top of girder.
M = total bending moment at center of span due to dead and live-load.

The assumptions as to the maximum allowable stresses in concrete and steel and the ratio of their moduli of elasticity give an expression which locates the position of the neutral axis.

$$\frac{x}{h-x} = \frac{m\,c}{f}$$

$$\text{whence } x = \frac{m\,c}{f + m\,c}\,h = \frac{11250}{16000 + 11250} = 0.413\,h$$

The concrete in compression above the neutral axis may be divided conveniently into two parts, that in the rectangular section, and that in the triangular sections formed by the fillets. According to the straight-line theory of the distribution of stress, the total compression in the rectangular portion of the girder is

$$P_c = \frac{c}{2}\,b_1\,x$$

and the centroid of this compression is one-third the depth of the neutral axis from the top of the girder.

The compression in the triangular areas is found in the following way: Call the sum of the widths of the two fillets $B = b - b_1$. Consider an elementary section at a distance z from the neutral axis, having a depth δz. The width of this section will be

$$b' = \frac{z - x + d}{d}\,B$$

The unit compressive stress in the concrete at this point will be

$$c' = c\,\frac{z}{x}$$

and the compression in the elementary strip is

$$p = c'\,b'\,\delta z$$

$$= \frac{c\,B}{x\,d}\,(z^2 - z\,x + z\,d)\,\delta z$$

Integrating this value between the limits $(x - d)$ and x, the total compression for the triangular areas is

$$P_c' = \frac{c\,B}{x\,d}\int_{x-d}^{x}(z^2 - z\,x + z\,d)\,\delta z$$

$$= \frac{c\,B\,d}{6\,x}\,(3\,x - d)$$

The moment of all the compressive forces in the triangular areas about the neutral axis is

$$M_p = \int p z$$

$$= \frac{c\,B}{x\,d}\left[\int_{x-d}^{x} z^3\,\delta z - (x-d)\int_{x-d}^{x} z^2\,\delta z\right]$$

$$= \frac{c\,B\,d}{12\,x}\left[2\,x\,(3\,x - 2\,d) + d^2\right]$$

The centroid of these compressive forces is then a distance from the neutral axis equal to

$$g = \frac{M_p}{P_c'}$$

$$= \frac{2\,x(3\,x - 2\,d) + d^2}{6\,x - 2\,d}$$

Having obtained the total compression in the concrete and the location of the individual centroids of compression, the object is to supply the proper amount of steel in the bottom of the girder to take care of the tension; and in case the concrete already provided in the top of the girder is not sufficient for taking up all the compression, to provide a suitable amount of steel in compression for the excess.

The moment of resistance of the section, expressed in terms of the concrete compression, is

$$M_r = M_c + M_c'$$

wherein $$M_c = P_c\left(h - \frac{x}{3}\right)$$

and $$M_c' = P_c'\,(h - x + g)$$

In case the bending moment M is greater than M_r, the difference between the two

$$M_s = M - (M_c + M_c')$$

must be supplied by the addition of steel to the compression side of the girder, the compression so supplied being

$$P_s = \frac{M_s}{h - a'}$$

where a' is the distance from the top of the girder to the center of the steel in compression.

The unit compressive stress in this steel will be

$$f' = c\,m\,\frac{x - a'}{x}$$

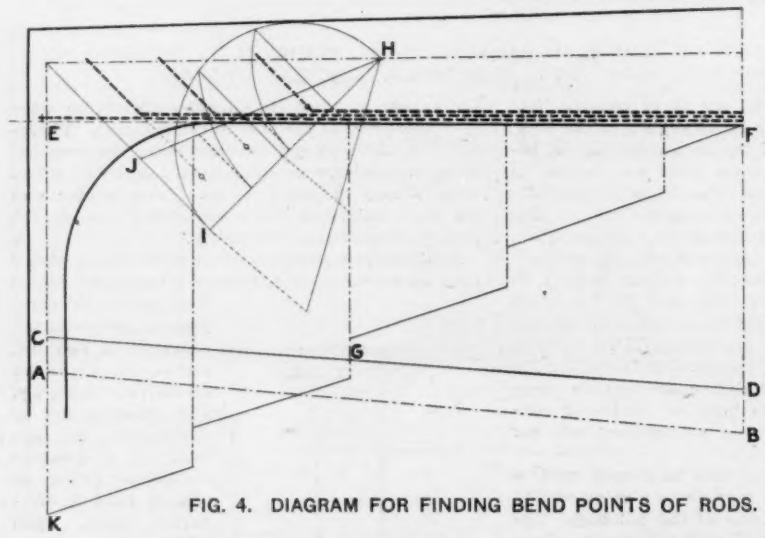

FIG. 4. DIAGRAM FOR FINDING BEND POINTS OF RODS.

The area of steel here necessary is, therefore

$$a_s' = \frac{P_s}{f_s'}\,\frac{m}{m-1}$$

$$= \frac{P_s\,x}{(m-1)\,(x - a')\,c}$$

Since the total tension in the steel in the bottom of the girder must equal the total compression,

$$T = P_c + P_c' + P_s$$

and the area of steel necessary in tension is

$$a_s = \frac{T}{f}$$

Following out these operations, with the given bending moment of 24,750,000 in.-lbs. at the centre of the span, it was found that 24.75 sq. ins. of steel were required in the bottom of these girders. Five 1¾-in. round rods and seven 1⅝-in. round rods were used. In the top of the girder two 1⅜-in. rods were used, as reinforcement against thermal stresses rather than because there was a deficiency of concrete in the compression area.

These rods varied in length from 75 ft. 4 ins. to 79 ft. 1 in., and were (with some difficulty) obtained from the mill in the required lengths, no splices having to be made. The seven 1⅝-in. rods were turned up at three different points toward the end of the span where they were not needed in tension, and beyond the point where the girder might be considered as needing reinforcement against internal stresses in the concrete. Four of these seven rods were bent down again at the end of the span, and, together with the two 1⅜-in. rods running along the top of the girder, were made continuous, by means of steel turnbuckles, with the six rods of the same size running up the outside face of the column from the footing.

Every possible advantage was given the girders by ensuring, as far as possible, continuity of action from footing to footing. The first 8-ft. height of the columns, ending at the floor-line, was poured shortly after the footings were completed. The column reinforcement began at the bottom of the footing and was carried a foot or two above the floor line, at which point it was deemed fair to assume that there would be little or no flexure in the columns under the worst conditions. In the interest of additional strength, however, the splices in the column reinforcement at this point were made with steel turnbuckles. The rods running up the outside face of the column were spliced in the same way to the four rods turned up from the bottom of the girder and the two rods running along the top, as previously stated.

The arrangement of the reinforcing steel is shown in full by the drawing Fig. 3.

Since the precise end-conditions of the girders are not known, and cannot be assumed with any degree of accuracy, no attempt was made at an exact computation of the stresses in the columns. What was actually done in reinforcing the columns was to use the steel that was available in a way calculated to act most effectively.

The column is 24 ins. square. The total load upon it is 104,000 lbs. If this were uniformly distributed over the column, a stress of 180 lbs. per sq. in. would result. It is not at all likely that this low compressive stress is increased to any dangerous degree by the possible flexure of the columns. Without considering the stress due to the direct load on the columns, and allowing 500 lbs. per sq. in. on the concrete in flexure, these columns, reinforced with four 1⅝-in. and two 1⅜-in rods would provide a resisting moment of 1,185,000 in.-lbs. Comparing this with the bending moment at the centre of the girder, 24,750,000 in.lbs., it is seen that the former is about one-twentieth of the latter, or in other words is equivalent to a moment of resistance of about

$$\frac{W\,L}{160}$$

The small rods on the inside face of the column are intended to serve as reinforcement against the possibility of contraflexure in the vicinity of the floor line and tensile stresses on the inside of the column between this point and the footing.

The placing of the large circular bracket at the end of the span connecting girder and column, serves to strengthen the structure at a point where it would be particularly weak without it, and doubtless eliminates structural weaknesses which otherwise might develop there.

BOND STRESS AND ANCHORAGE.—The adhesive or bond stress developed by the five 1¾-in. rods which run along the bottom of the girder, when figured in the ordinary way, is much lower than might be expected from the use of such large rods. This stress, figured for the worst possible case, with an end reaction of 104,000 lbs. and a distance of 47.5 ins. between the centres of compression and tension at the end of the span, is

$$f_a = \frac{104{,}000}{5 \times 5.5 \times 47.5} = 80 \text{ lbs. per sq. in.}$$

In girders of moderate span this adhesive stress could not be considered excessive, considering

the excellent quality of the concrete. Furthermore, the practical assurance that there will be a considerable negative bending moment at the end of the span would lead one to believe that no adhesive stress whatever will be developed by the rods at this point. Yet the meagerness of our knowledge of the action in setting and hardening of large and long masses of concrete reinforced with rods of large size, and the possibility of an imperfect bond between the two materials, was considered of sufficient importance to make necessary the use of positive anchorages in the form of heavy anchor plates on the ends of the rods. These plates were designed to develop the full working strength of the rods, the area of the plates being proportioned for an allowable bearing on the concrete of about 1,200 lbs. per sq. in., and a bending stress in the plate of about 22,000 lbs. per sq. in.

SHEAR REINFORCEMENT.—Although nothing definite can be stated in regard to the nature and magnitude of the internal stresses and strains in a concrete beam or girder, various attempts have been made to reinforce such structural members against what is commonly known as shear, or more correctly diagonal tension. This reinforcement generally takes the form of vertical stirrups near the end of the span, which are almost always spaced by means of more or less arbitrary rules, and quite often by empirical rules based upon the assumption of direct shear between the concrete and the stirrups. The mere absurdity of such an assumption, however, cannot be said always to be productive of bad results in actual design; and in ordinary cases a design based upon such rules may be as good as one based upon rules more logical, but more difficult of application. In members of large size, wherein it is important that every care should be exercised toward perfectly safe designs, it becomes more important to recognize at least the nature of the important internal stresses, and to provide sufficiently against them.

Often a careful examination of the designs for reinforced-concrete buildings reveals the fact that the commonly accepted permissible unit stresses for shear and adhesion are far exceeded, although an attempt may have been made to cover up the deficiency by the use of stirrups in such number as some empirical rule may have dictated. The use of such rules sometimes leads to the approval of beams and girders which obviously are deficient in concrete. It is the belief of many engineers that it is false economy as well as bad engineering to allow the use of high unit-stresses and the small beam sections consequent upon their use.

The simplest and most effective way in which to reinforce beams and girders against diagonal tension is by utilizing the metal already available in the tension side, turning this metal up at an angle of about 45° so that it will pass through the web at right angles to the planes of maximum tension. Rods so disposed are undeniably in tension, and there seems to be no good reason why they should not be looked upon as furnishing the reinforcement for which stirrups have for such a long time been considered essential. These turned-up rods are anchored positively at both top and bottom, especially when they are carried over the tops of the supports for the purpose of producing continuity of action. The only plausible ground upon which reliance on turned-up rods as reinforcement against diagonal tension might be attacked, is the fact that such reinforcement is highly concentrated at a point or at several points, and can have only a local effect. Fortunately, however, tests made for the purpose of comparing the relative efficiency of beams reinforced against internal stresses by the ordinary method of using stirrups, and by utilizing the turned-up rods for this purpose, show that the latter method is no less effective than the former in its practical application.

The following is the method used in locating the bends in the rods of the girders described in this article. It is essentially the same as that used by many German engineers. It cannot be said that it is absolutely correct, inasmuch as it is based upon assumptions which may or may not be justifiable. But it offers what seems on the whole to be a more logical and clearer view of a difficult and serious problem than has heretofore been presented in these columns, and is here given in hope that it may be developed still further by others.

The concrete of which these girders were made was considered to be good for an actual working direct shear of 65 lbs. per sq. in. without any particular need for reinforcement. At the point where the unit-shear became greater than 65 lbs. per sq. in. it was thought advisable to provide special web reinforcement by turning up a part of the rods from the bottom of the girder near the end of the span. There was assumed to exist in the concrete at the neutral axis a maximum (diagonal) tensile stress of the same magnitude as the permissible unit-shear, 65 lbs. per sq. in. and the diagonal tension in excess of this amount was considered to be taken care of by the rods which were turned up from the bottom of the girder.

These assumptions are purely arbitrary, and are made only for the purpose of obtaining a basis upon which to work, with the utlimate idea of showing that, if the maximum diagonal tensile stress in the concrete is 65 lbs. per sq. in., the tensile unit-stress in the turned-up rods will not be excessive, by which is meant a stress somewhat below 10,000 lbs. per in.

For convenience let us consider the two common standards for determining the shearing value of the section of a concrete girder. The apparent, or vertical shearing value, may be stated as the product of the area of the section and a certain allowable shearing unit-stress. Thus

$$V = f_s\ b_1\ h$$

wherein f_s = the said allowable stress, b_1 = the breadth of the section, h = the depth from the top to the steel. The real, or horizontal shearing value for the section may be stated, for purposes of comparison with the first to be $V' = f_s\ b_1\ h'$ where h' is the distance from the center of compression to the center of the steel. This value is

$$V' = V\frac{h'}{h}$$

and may be considered as the safe external shearing force which the girder can safely withstand at a given section; if an external shear greater than this is applied, measures must be taken to remedy the weakness in the girder thus disclosed.

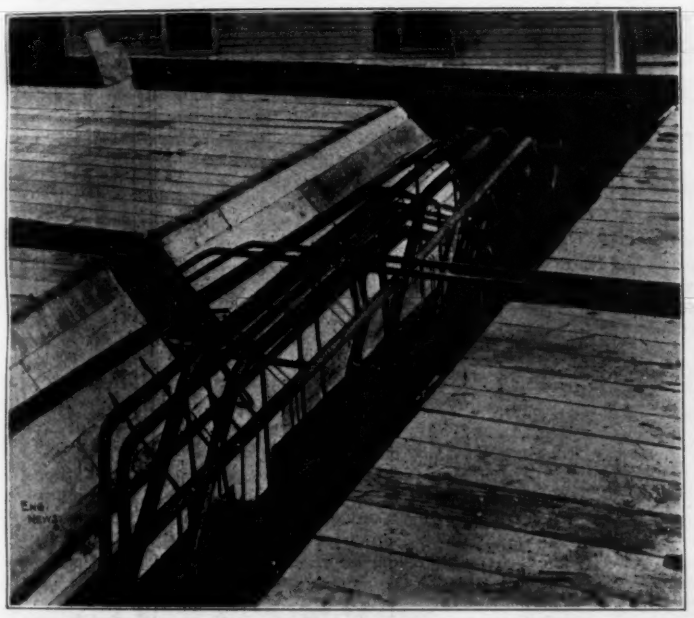

Fig. 5.

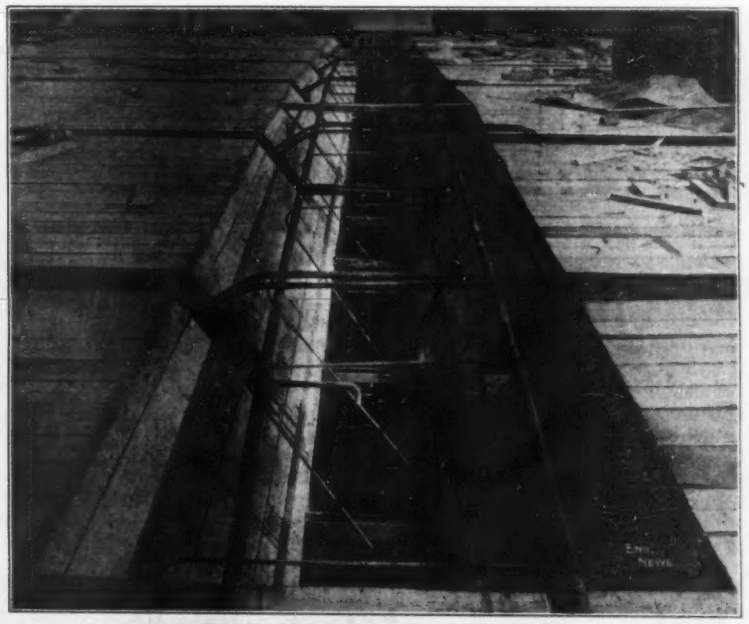

Fig. 6.

FIGS. 5 AND 6. TWO VIEWS OF INTERIOR OF GIRDER FORMS, SHOWING REINFORCEMENT IN PLACE.

In Fig. 4, distances measured vertically from the line *E-F* to the line *A-B* represent the apparent shearing values of the girder, figuring only the rectangular section. At the end of the span this value will be

$$65 \times 18 \times 57 = 66{,}700 \text{ lbs.},$$

while at the centre of the span the apparent shearing value is

$$65 \times 18 \times 70 = 81{,}900 \text{ lbs.}$$

The centre of compression for the section at mid-span is 0.86 of the height above the steel. This figure also will be assumed to be correct for the section at the end of the span, and for all other sections. The real shearing value for the end section is therefore

$$66{,}700 \times 0.86 = 57{,}400 \text{ lbs.}$$

and the real shearing value for the section at mid-span is

$$81{,}900 \times 0.86 = 70{,}400 \text{ lbs.}$$

Vertical distances measured to the line *A-B* represent the apparent shearing values of the girder; these are assumed to increase at a constant rate from the end of the girder to mid-span. Likewise, vertical distances measured to the line *C-D* represent the real shearing values. Vertical distances measured to the broken line *K-F* represent the external vertical shears to which the girder is subjected.

As previously stated, the maximum diagonal tension in the concrete at any position along the girder is assumed to be of the same intensity as the maximum horizontal shear, and occurs at the

neutral axis on a plane inclined 45° to the horizontal. The place at which this internal stress is considered to become of sufficient magnitude to require attention is directly above the point at which the external shear diagram at *G* intersects the real shearing value diagram. If the girder carried no concentrated loads, and had an unbroken external shear diagram, this critical point would be defined with an accuracy in keeping with the correctness of the assumptions upon which the theory is based.

In the case in hand it can be seen that the critical point comes directly under a concentration, and that a very decided change in the depth of the girder would be necessary to move this point either one way or the other. It is obvious, then, that in order to provide sufficiently for this abnormal shearing stress which perhaps occurs at this point on account of the sudden increase in the rate of change of bending moment, the critical point should be considered as somewhat further toward the center of the span.

From this critical point toward the end of the span there is a gradual increase in the diagonal tensile stresses. At the end of the span the maximum horizontal shear is

$$f_s = \frac{V}{b_1 h'}$$

$$= \frac{104{,}000}{18{\cdot}49{\cdot}} = 118 \text{ lbs. per square inch.}$$

The maximum diagonal tension at this point is also 118 lbs. per sq. in. The difference between this and the allowable stress of 65 lbs. per sq. in. is 53 lbs. per sq. in., which is the maximum excess diagonal tensile stress in the concrete.

Conceive now a series of small planes along the neutral axis which are inclined 45° to the horizontal, and upon each of which there is an excess diagonal tensile stress in proportion to its distance from the critical point. Calling the distance from the critical point to the end of the span *l*, and neglecting the inclination of the neutral axis due to the variation in the depth of the girder, the projection of these small planes upon a plane parallel to them and passing through the critical point, is an area equivalent to the sum of their areas, and upon which there is a normal tensile stress varying from nothing at the critical point to a maximum of 53 lbs. per sq in. at the end of the span.

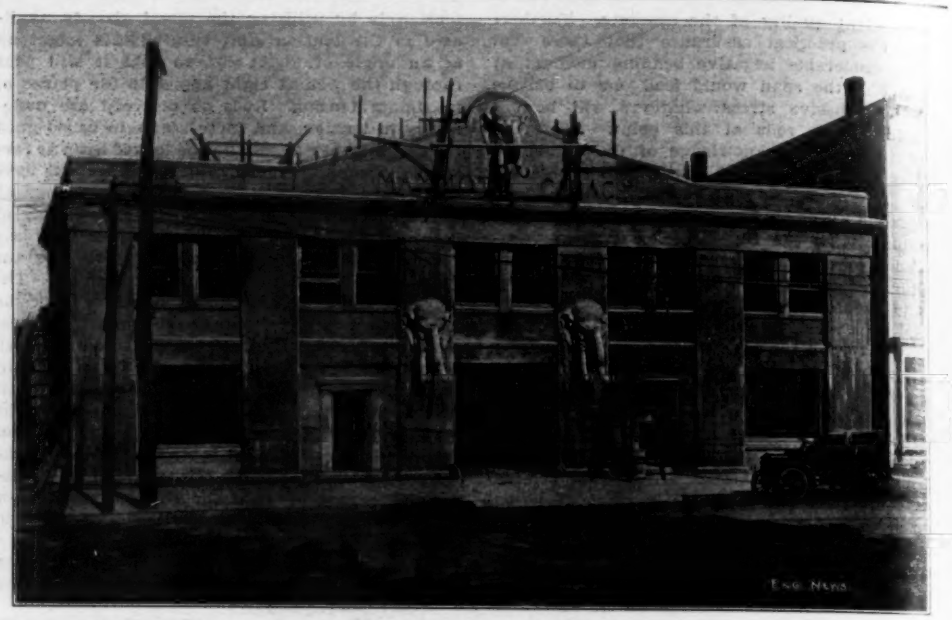

FIG. 8. THE "MAMMOTH GARAGE," WHITE PLAINS, N. Y.

The area thus considered is $A = b_1 \, l \cos 45°$. Since l is 18 ft. and b_1 is 18 ins., the area is $A = 18 \times 18 \times 12 \times .707 = 2{,}748$ sq. ins. and the total tension normal to this plane which must be taken by the turned-up rods is

$$2{,}748 \times \frac{53}{2} = 72{,}800 \text{ lbs.}$$

Representing this tension by the triangle *H I J*, the points at which the seven 1⅝-in. rods, are turned up from the bottom are located by dividing the triangle into zones, each proportional to the area of metal considered to be acting in its particular zone; the rods are then passed through the centers of gravity of the respective zones.

Since the total area of metal turned up is 14.51 sq. ins., the unit stress in these rods may be considered to be

$$\frac{72{,}800}{14.51} = 5{,}000 \text{ lbs. per sq. in.}$$

Actually it is quite impossible to show whether the stress in the turned-up rods is greater or less than the above figure, or whether the maximum diagonal tension in the concrete is greater or less than 65 lbs. per sq. in. To offset this lack of absolute knowledge we do know that the more commonly figured stresses are not excessive when compared with the standards of good practice, and that, in all events, the conditions at the end of the span are by no means as severe as they would be if there were no continuous action between the girders and the columns.

The rods might have been turned up one at a time, thus to distribute the available metal more evenly through the concrete where it is thought to be needed. This was not done because of the unwarranted complication which would have resulted in bending the rods.

The forms for these girders were built so as to give them a camber of 4 inches at the center of the span, this being considered amply sufficient to offset any deflection which the girders might be expected to sustain, and at the same time give them a residual camber great enough to avoid the appearance of sagging.

The girders were poured, each in one continuous operation consuming a whole working day, the columns having been poured the day previous up to the beginning of the circular brackets to allow of the proper settlement of the concrete in the forms before continuing with the pouring of the girder. When the falsework was removed from the six girders after six weeks the deflection noted at the center of the spans was approximately 0.01-in. in each case.

The work above described was done by the owners, the Mammoth Garage Co. The excellent quality of the work and the success attained in the construction of the long spans was due to the careful way in which the superintendent, Mr. Hans Hilton, worked out the details for the falsework and handled the whole undertaking.

FIG. 7. INTERIOR VIEW OF AUTOMOBILE STORAGE ROOM, SHOWING 75-FT. REINFORCED CONCRETE GIRDERS.

A POWERFUL DREDGE of the barge-loading type, named the "Premier," has recently been built by Messrs. Wm. Simons and Co. of Renfrew, Scotland. A brief description is given in the October issue of the "Iledian and Eastern Engineer." The vessel is of the bow-wall bucket-ladder type, well equipped for dealing with heavy work, and is capable of dredging to a depth of 50 ft. below water level. A set of compound marine engines, with steam supplied from a multitubular steel boiler at 120 lbs. pressure, drives the dredging machinery, which is designed for a nominal lifting capacity of 1,200 tons of spoil per hour. The deck machinery includes steam gear for raising and lowering shoots fitted on either side of the vessel, powerful bow and stern winches, and steam capstans on either side of the vessel fore and aft for bringing the barges alongside.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS AT NEW YORK.

The 28th annual meeting of the American Society of Mechanical Engineers was held last week at the new United Engineering Societies Building, 29 West 39th St., New York City. It was the first annual meeting held in the elaborate new building provided by the munificence of Mr. Andrew Carnegie. The annual meetings of 1905 and 1906 had a phenomenally large attendance, but the convention last week showed a still higher record. The total registration of members was about 725, with nearly an equal number of guests.

As usual, the meeting opened on Tuesday evening with a session for the presentation of the annual Presidential Address. Last year, it will be remembered, Mr. F. W. Taylor, the retiring president, distinguished this occasion by placing before the world the results of his experimental research into the laws of metal-cutting, a research extending over more than twenty years. In consequence his successor, Prof. F. R. Hutton, faced the embarrassing duty of attempting to live up to the standard of presidential addresses set by Mr. Taylor. He ingeniously avoided the difficulty by choosing a subject so different in character as to discourage even unconscious comparison, though the subject is perhaps little less ambitious than Mr. Taylor's. The address was entitled "The Mechanical Engineer and the Function of the Engineering Society"; essentially it represented an attempt to define and study the field of activity of the American Society of Mechanical Engineers, and, partly for this purpose, to define the term "Mechanical Engineer." The address is extremely lengthy and enters into much detail interesting to few outside of the society itself. Incidental to the definition of "Mechanical Engineer," it contains an analysis of the membership of the society, as to occupation, which is summarized as follows:

Occupation Group.	Numbers.		Percentage.	
Unclassified	306		10.3	
Army and navy	11		0.4	
and marine	18		0.6	
Hydraulic	12		0.4	
Patents	25		0.8	
Journalists	30		1.0	
Mining and metallurgy	31		1.0	
Engineering contractor	48		1.6	
Testing and inspecting	49		1.6	
Operating engineer	55		1.8	
Locomotive and railway	57		1.9	
Electrical engineer	65		2.2	
Professor and teacher	185		6.3	
Draftsman and designer	115		4.0	
Local manager	153		5.2	
Shop executive	338	1,572	11.8	53.6
The manufacturer	966		32.6	
Office practitioner	493		16.5	
Total	2,957		100.0	

The bracketing of the four groups preceding the last, with a total of 1,572 persons or 53.6% of the total of the list, is intended to emphasize the fact that the largest group in the society is formed by men who are engaged in either the commercial or the technical direction of manufacturing establishments, chiefly machine shops. The list given covers only the American membership of the society, the total membership at the period corresponding to the tabulation being 3,152.

The meeting began its serious work early on Wednesday morning, Dec. 4, with a business and professional session. Further professional sessions were held on Thursday morning and afternoon, and on Friday morning. The first session had lagged so far behind its schedule that a double session was held on Thursday morning, sections on power-production and on foundry practice meeting simultaneously in adjoining rooms.

That part of the time not occupied by meetings was fully utilized in social enjoyment and excursions. The general reunion on the evening of the Presidential Address was in itself a part of the social half of the meeting. A lecture on "Color Photography" on Wednesday evening, and the annual reception on Thursday evening were the other social features. "Social and intellectual attrition with other minds," as the Presidential Address phrased it, was also in progress at several collations and midday lunches which the facilities of the new building made possible. Of the excursions provided by the local committee the most interesting was a trip through the Hudson River Tunnel (Morton St. tunnel), under the guidance of Chief Engineer Charles M. Jacobs. Numerous shops and works in and about New York invited the members to visit them, and individual parties were formed for such visits.

The business work of the meeting was confined practically to the election of officers. Mr. M. L. Holman (St. Louis, Mo.) was elected President; Prof. L. P. Breckenridge (Urbana, Ill.), Mr.. Fred J. Miller (Center Bridge, Pa.) and Mr. Arthur West (East Pittsburg, Pa.), were elected Vice-Presidents; Messrs. W. L. Abbott (Chicago, Ill.), Prof. A. C. Humphreys (Hoboken, N. J.) and Mr. H. G. Stott (New York City) were elected Managers; Mr. Wm. H. Wiley (New York City) was re-elected Treasurer.

The annual reports of the Council, etc., were presented by title or abstract only, pending publication in the "Proceedings."

The professional work of the meeting was divided into two fairly distinct portions, one concerned with Power Production, the other with Foundry Practice. This division is adhered to in the following brief review of the proceedings.

POWER PRODUCTION.

THE RATIONAL UTILIZATION OF LOW GRADE FUELS IN GAS PRODUCERS.—This paper by Mr. F. E. Junge described European practice in the utilization of the poorer grades of fuels and explained the advantages of gas producers in utilizing such fuels. The author maintained that in speaking of lignite and peat of low carbon, high moisture and high ash contents as low grade fuels, tradition was followed rather than recent developments. It was asserted that the only true low grade fuels were in the culm and waste banks of coal mining regions where utilization has been out of the question on account of the excessive ash content.

The recovery and utilization of by-products from gas works in Germany was stated to be ahead of practice in this country. In speaking of the utilization of peat, the author regarded as mistakes all attempts at the utilization of peat as a fuel only and not also as a container of valuable by-products. He even stated that peat deposits, to be rightly used and conserved, should be treated as agricultural aids and not as sources of heat, power or light. In spite of this statement the author showed the lines along which the Mond producer and the Zeigler peat coke processes have been successful.

The use of mine culm, wash banks, etc., in Jahn's ring producers was mentioned as being successful at the von der Heydt Mines, Saarbrücken, Germany. At this plant power is developed at a cost of 0.05 ct. per B. HP. hour.

In speaking of the briquetting of coke breeze and dust coke the case of the Riga Gas Works was cited.

Large piles of dust coke had been sold as filling materials, fetching a price of 2.5 cts. per 100 lbs., while coke in the larger sizes would sell at 30 cts. per 100 lbs. in that locality. A briquetting machine was installed which produced 1,000 briquettes (880 lbs.) per hr. The addition of 5% of hard pitch and tar residues as binder gave sufficient cohesion. The average production in a 10-hr. day was 9,240 lbs. of briquettes having a heat value only 5% lower than coke. By the adoption of these methods of utilization, the returns from this low grade material have been increased from 55 cents per ton to $3.

In discussing this paper Dr. J. A. Holmes, Chief of the Technologic Branch of the Geological Survey, spoke briefly of the wasteful American methods of coal mining which the Geological Survey investigations had brought to light. He stated also that the President had recommended, in his recent message, a bureau of mining and engineering investigations to be under the combined direction of the larger engineering societies.

Prof. C. E. Lucke, of Columbia University, maintained that gas producer power plants were not strictly commercial as yet, because they were too expensive, because the operating labor was excessive, and because continuity of action was broken by the need of frequent cleaning out, which necessitated many spare units.

Mr. J. R. Bibbins, of the Westinghouse Machine Co., mentioned some experiments at East Pittsburg, Pa., undertaken at the instigation of an anthracite operator who desired to generate electricity at the mine rather than to transport anthracite in "rice," "buckwheat" and "barley" sizes. Such coal was used in a producer designed for sizes no smaller than pea. On account of the fineness a reduced depth in the fuel bed was necessary. A day's trial with culm mixtures showed the inadvisability of using straight culm. With fuel of 23 to 30% ash content and a heat value of 6,750 B.T.U., 105 to 127 heat units (effective) per cu. ft. of gas were produced.

Prof. R. H. Fernald, Technologic Branch United States Geological Survey, mentioned the results of government comparison tests of Illinois coals under boilers and in gas-producers. These tests showed that the thermal efficiency of the entire steam plant was under 4% as compared with about 13½% for gas power plants. The best steam plant that he knew anything about had a thermal efficiency of about 10.3%. The best gas-producer plant has a value of 21.5%. These experiments on a fuel of 4% ash had shown a consumption of 1.65 lbs. per HP.-hr. in a producer designed for anthracite. He stated that a year ago there were 150 gas-producer power plants in the country, while now there were 400 (average size, 1,600 HP.) working mostly on bituminous coals. The first cost of complete plants as determined in the course of government investigations was 15 to 30% greater than for steam plants in capacities less than 1,000 HP. Between 1,000 and 5,000 HP. the cost of the gas power plant was from 10 to 15% greater and above 5,000 HP. the figures were almost the same.

DUTY TEST ON A GAS POWER PLANT.—This paper by Messrs. G. I. Alden, of the Norton Co., Worcester, Mass., and J. R. Bibbins, Westinghouse Machine Co., East Pittsburg, Pa., showed the tests made in June, 1907, on a 500-HP. gas-power plant for furnishing electric current. The test was on service runs during the daytime with the power equipment in charge of the regular operating force. To shorten the period of test, load was maintained during the hours from 6 p. m. to 7 a. m. The main object of the test, as stated, was to determine the thermal efficiency of the plant during a long run at full load under service conditions. In determining this figure there was also obtained the thermal and mechanical efficiency of the engine and producer alone at various loads, the water and oil consumption of the engine, etc., during the 51-hr. test, made without interruptions, a load of 11% over the generator rating was held. This gave about 483 B. HP. on the engine, or nearly full load. The actual coal consumption found was 1.4 lbs. per KW.-hr., or 0.97 lb. per B. HP.-hr. on Clearfield bituminous, run-of-mine, having a value of 14,320 B.T.U. per lb. The average heat value of the gas (by calorimeter) was 114.6 B.T.U. per cu. ft.

The engine developed 25.3% thermal efficiency at full rating.

CONTROL OF INTERNAL COMBUSTION FOR GAS ENGINES.—In this paper Prof. C. E. Lucke, Columbia University, stated that there were conditions affecting the working of gas engines that were beyond the control of present governing apparatus. These were all combustion effects and were shown on the combustion line of the engine cards. These were (1) pre-ignition, (2) variations in the mixture of gas and air, and (3) explosive waves, whereby successive maximum and minimum points in the combustion process were present.

The cylinder mixture was shown to be one of air, gas and burned gases, variations in whose proportions affected the combustion line of the engine card. Lack of homogeneity was shown in mixtures having the same total constituents. The conditions leading to this lack of homogeneity were dependent on the orifices through which the gas, the air and the resultant mix-

ture passed in reaching the cylinder. One paragraph of the paper expresses this:

It appears to be an extremely difficult proposition to secure constant weight proportion between two gases flowing through two orifices into a partial vacuum through openings of different sizes and shape under heads compounded of the vacuum and the gas pressure with variable rates of flow, changes of barometer, gas pressure and the temperature of both gases and it is not surprising that variations occur, but rather more surprising that the results are as uniform as they are. After having proportioned the air and the gas, the mechanism delivers it into a cylinder through a valve to an irregular head or clearance space where it mixes more or less uniformly with the neutral gases therein. These residual gases may have the same composition on successive strokes or may not, depending upon a variety of circumstances, some uncontrollable, such as diffusion, others under practical control, such as point of ignition and back pressure.

The explosive waves were shown to start when the cylinder mixture became agitated either by streams of gas resulting from pockets in the combustion chamber or by compression waves induced by the motion of the piston. It was stated that the presence of such waves could be shown on the indicator card of any engine if between the engine cylinder and the indicator there was connected a pocket, with a small throat, such as might be made of pipe fittings. The occurrence of such waves was held to be an element of danger and of interference with the control.

The third disturbing action, pre-ignition, is the premature explosion when the mixture ignites itself before the piston reaches a dead-center position.

Besides the many known easily avoidable causes, there are some that are difficult to understand. Any inward projecting part, such as a piece of asbestos gasket or rough edge of the casting, a bolt head, nut, piston compression plate, carbonized oil or possibly an ignitor, may get so overheated as to cause ignition. The compression causes a temperature increase, so that all parts of the gaseous mixture, except those directly in contact with cold walls, will suffer the same temperature rise, due to the compression. If this is near any particle of the mixture another source of heat than the compression, the temperature at that place will rise higher and may rise so much higher as to cause an ignition. It may be also that lack of homogeneity in the mixture will result in zones where the mixture has a lower temperature of ignition than at other places, for example, in places where lubricating oil is vaporizing or in the case of gasolene where the mixture is a little more rich in gasolene. This is another cause. In spite, however, of these traceable causes there seem to be some others, and these are mostly associated with the percentage of hydrogen in the gas.

At one time it was believed that the temperature of ignition of hydrogen was so low that the addition of hydrogen to a gas not previously containing it would lower the temperature of ignition of the mass, and designers, including the writer, went so far as to announce figures for the reduction of compression for each per cent. of hydrogen present that was necessary to prevent pre-ignitions. Repeated experiments by the different engine builders and by engineers not associated with the building of engines point conclusively to the fact that pre-ignition may occur when the percentage of hydrogen is low and may not occur when it is high and again may occur when it is high and may not when it is low for a given engine running on a given compression. There seems to be substantial agreement on the statement that if the hydrogen were absent there would be no pre-ignition at this compression.

The ignition temperatures of explosive mixtures were determined experimentally by dropping a weight on a plunger, closely fitting a cylinder containing the mixture. The apparatus was arranged to measure the plunger travel up to the point of explosion. The temperature was then computed by the adiabatic law from the volume in compression when the ignition took place by compression alone. It was stated that these results showed that the ignition temperatures of complex mixtures was fixed by the ratio of two of its components to each other, all others acting to raise the temperature as inert or neutral gases. Formulas were worked out by which the ignition temperatures of the H and O and CO and O mixtures might be found. Concerning the results of the Columbia experiments the author stated that

These explain the apparent inconsistency between percentage of hydrogen in the gas and the conditions of pre-ignition. It appears from the figures given for the temperature of ignition that in a producer gas containing hydrogen and CO with various neutrals mixed with oxygen the temperature of ignition does not depend on either the hydrogen necessarily nor the CO necessarily in the mixture, but on the relation that one of these bears to the oxygen present and which one can be determined only by computing the temperatures of ignition for both and taking that value which is lower.

However, in these experiments the ignition temperatures, for all such explosive mixtures as would be expected in a gas engine cylinder, is far below the temperature coincident with compressions of practical engines. It is then evident that pre-ignitions are due also to other sources of heat. The author stated that the interior parts must be hot enough in places to materially augment the temperature produced by compression. It was held likely that all heat effects for some one part of the cylinder with the presence of some sensitive proportion, in the mixture, between the oxygen and either the CO_2 or H were made responsible for the pre-ignitions.

As solutions of the three troubles, pre-ignition, explosive waves and non-homogeneous mixtures, the author proposed:

(1) (a) Maintenance of proportion of the elements of the mixture to those having the higher temperature of ignition, provided this mixture will still contain enough oxygen to burn all the fuel present; (b) Care in securing as low an initial temperature of the mixture as possible by maintaining inlet passages cool and purging the cylinder as completely as possible of burnt gases. This also involves the maintenance of early ignition to reduce final release temperatures. (c) Care in designing the machine so that interior parts shall be as well cooled and as uniformly cooled as possible. A well cooled cylinder with one spot, such as a nut, poorly cooled may just as well be poorly cooled throughout.

(2) The prevention of explosive waves entirely in engine cylinders seems to be impossible. They can be avoided to a large extent and practically eliminated by giving attention to the form of the combustion chamber and to the method of igniting so as to avoid the generation of successive waves that might superimpose, but precisely how this is to be done cannot be said at this time, and more research will be required before a solution is possible.

(3) The maintenance of uniform cylinder mixtures involving, as it does, first, the correct and positive proportioning of air to gas, and later, the uniform mixing of this primary mixture with the burnt cylinder gases in always constant quantities, is a thing which is absolutely impossible with the present type of engine.

There was little important discussion on this paper. A few individuals expressed the opinion that possibly some of the explosion wave effects in the combustion lines of the indicator cards were to due to inertia in the indicator springs. In closing, Professor Lucke admitted the action of spring vibration in merely heightening the effect of the waves on the card.

EVOLUTION OF THE INTERNAL COMBUSTION ENGINE.—In this paper Mr. S. A. Reeve, of New Haven, Conn., outlined what seemed, in view of the history of engine developments, the probable lines of future design of the gas engine. It was stated, at the outset, that the development of both steam and gas engines had conformed to the demands for greater reliability and flexibility rather than for better thermal efficiency. The author predicted that reliance on liquid and gaseous fuels would increase, rather more than would the direct use of solid fuel, and that while better thermal efficiencies in future gas engines would be attained, they would be incidental to the progress along other lines of design. This advance was believed to be toward greater reliability, toward a wider margin of power at full load efficiency, toward quicker governing action and toward reversibility.

To attain results along some of these lines the author showed a possible design of a modified simple Otto type having variable clearance spaces. A design of a Joule-cycle engine along steam-engine lines was also indicated.

THE SPECIFIC HEAT OF SUPERHEATED STEAM.—Prof. C. C. Thomas, of Cornell University, presented, mostly by means of curves, the results of several years' experiments to determine the true specific heats of superheated steam and to find their laws of variation. The paper describes the preliminary and final forms of calorimeters employed. The methods of conducting the experiments are disclosed. It was finally found necessary to devise a very simple calorimeter, electrically heated, with a single thermo-electric junction introduced immediately into the steam to accurately measure the temperature. The sources of steam and electricity were under control of a single operator stationed at a table where all readings were taken.

Without describing the elaborate and numerous experiments it may be said that the general conclusions reached were:

(a) The specific-heat of superheated steam varies with with both pressure and temperature. It increases when the pressure of the steam increases and diminishes with an increase in the temperature.

(b) The specific heat increases and decreases more rapidly when near the saturation point, with increase of pressure and temperature, respectively, than is the case in conditions more remote from the saturation point.

(c) These conclusions apply over the whole range covered in the present investigation, which includes pressures from 7 lbs. absolute to 500 lbs. absolute per sq. in. and up to 270° F. superheat, for all pressures employed.

(d) The Mollier Heat Diagram developed forms a graphical steam table, the superheated region of which has been calculated from the results of the present investigation.

The discussion on this paper crystallized into a motion that the research committee of the society should assist and promote further studies in the fields of superheated steam.

ENGINE DESIGN ADAPTED FOR THE USE OF SUPERHEATED STEAM.—Mr. Max E. R. Toltz, of St. Paul, Minn., in this paper mentioned the well-known advantages of superheated steam in engines and discussed the peculiarities of design made necessary by its properties. It was stated that owing to difficulties in lubrication, the Corliss valve could not be used at temperatures where superheated steam brought desirable economies. Double and four-seated poppet valves and the tandem type of engine were recommended. The pistons should have three wide rings and in horizontal engines they should be guided and supported by an extended piston rod. According to the author the piston should be lubricated directly and the piston rod should have metallic packing. No steam jacket was considered necessary for the high pressure cylinder and the material of all cylinders should be uniformly distributed to care for the expansion.

Much of the discussion on this paper turned on the permanent expansion of cast iron in contact with saturated steam and on methods of compensation. Mr. H. H. Supplee stated that it was very evident that engines for use with superheated steam were to be designed more toward present gas-engine lines, with every opportunity for easy lineal expansion. Prof. C. E. Lucke asked the costs of poppet valve engines and the expense of maintenance and lubrication over present practice. In response to these questions during the discussion there were mentioned three 1,000-HP. engines at Lancaster, Pa., built by the Providence Engine Works. It was stated that the poppet-valve construction was less costly than the Corliss type. No trouble had been found in getting a good lubricating oil for this service. After three or four weeks the permanent expansion had all been taken up. The design of the engines allowed for this feature and no trouble had occurred. The decrease in boiler capacity necessary compensated for the cost of the separately fired superheater.

CYLINDER PORT VELOCITIES.—Prof. J. H. Wallace, of the University of Colorado, presented in this paper a method of fixing some characteristics of a valve gear to establish a constant velocity of steam through port openings. This was accomplished by a series of valve diagrams based on what is known as the Bilgram type.

FOUNDRY PRACTICE.

THE FOUNDRY AND THE DESIGN DEPARTMENT.—Mr. Wm. A. Bole (Pittsburg, Pa.) opened the work of this section with a paper, "The Foundry Department and the Department of Engineering Design." The paper proved to be a recital of the possibilities of trouble in the foundry due to large variations in wall thickness of castings, softness or porosity in the upper portions of castings due to "bleeding" down into the body as shrinkage proceeds, and other actions well known to all who are familiar with the workings of a foundry. As the author suggests, such troubles are most apt to give trouble in large castings, and do not affect

small castings materially, partly due to the lower strength resulting from slow cooling, and partly due to the fact that small castings have usually a large excess of metal for various reasons. The particular argument made by the author was that the foundry and the drafting-room should be in close touch at all times, so that designs may always embody a due consideration of the requirements of the foundry. This would also lead the draftsman to pay attention to such matters as placing flanges and other projections in such a position as to save cost of pattern work and molding, and on the other hand it would prevent the foundry's putting chaplets through a cylinder wall or in a planed slide.

IMPROVING MOLDING SAND BY MECHANICAL TREATMENT.—The next paper discussed a matter of recent discovery. This paper was "The Improvement of Molding Sand by Mechanical Treatment," by Mr. A. E. Outerbridge, Jr. (Philadelphia, Pa.). It described in brief form the discovery made some years ago in the foundry of Wm. Sellers & Co., Inc., that the strength and the uniformity of molding sand is increased by riddling. The same effect, it was then found, can be secured by shaking the sand, or commingling and comminuting it. A machine was devised to do the work by this method, and when it proved a success in the Sellers foundry it was put on the market as a commercial machine. It consists essentially of a horizontal plate studded with many upward-projecting rods or prongs, which plate is adapted to rotate rapidly on a vertical shaft. The sand to be treated is fed upon the center of the plate by a hopper above, and when it is caught by the plate it is thrown outward against the prongs and finally over the edge of the plate. A bell-shaped hood over the plate deflects the shower of sand downward. These machines are made with several different arrangements for driving, as belt, electric motor in base, etc.

The increased strength produced by mechanical treatment of the sand, whether by such a machine or by riddling, etc., is readily shown by beam tests, for which the author has devised a very simple method. The sand is molded into bars 1 × 1 × 6 ins., under uniform conditions of dampness and pressure, and these are laid on a smooth sharp-edged metal plate. To make the test they are pushed endwise over the edge of the plate, very slowly, until the overhanging part breaks off. The length of overhang measures the strength, though as both weight and lever-arm increase with the overhang, the strength evidently varies as the square of the overhang. In one test cited by the author to show the effect of mechanical treatment, the breaking overhang of new sand before treatment was 2¼ ins., while treatment increased it to 3 ins. and after a number of repeated treatments to 3¾ ins.

The discussion of the paper constituted a general confirmation of the value of mechanical treatment of molding and core sand.

POWER EQUIPMENT.—Under the title "Power Service in the Foundry," Mr. A. D. Williams, Jr. (Pittsburg, Pa.), argued for more thorough attention to the various economies in time and labor made possible by the use of properly planned handling appliances in the foundry. An ample supply of crane facilities was mentioned as particularly important. Wall cranes, or jib-cranes adapted for shifting from one column to another, in conjunction with a single level of bridge cranes, were recommended by the author as giving the maximum facility of crane service. In the matter of distribution of power for general purposes in the foundry, the author suggested various advantages and disadvantages of electric, air and hydraulic distribution.

Some of the author's statements in this connection are as follows:

> As generally installed, with a central compressing plant, the use of compressed air requires an expensive transmission line, and in addition it is impossible to avoid leakage in the joints. Compressed-air leakage does not show, and the pipe lines for this purpose as usually constructed are designed to remain tight only long enough to pass the acceptance test. . . . Except in the large sizes, air-compressors are steam eaters like steam pumps.

In reply to this, Mr. Frank Richards (New York) submitted a strong defence of compressors and compressed-air pipe lines. Some 80 air-compressors, aggregating 190,000 cu. ft. of free air per minute, representing a power of about 40,000 HP., are in use in the various tunnel enterprises now going on in New York City. These compressors have been worked almost continuously, in service where reliability is the first consideration, without any case of failure. In one of the large undertakings associated with these tunnels, the Pennsylvania R. R. Terminal excavation, air is piped all over the working area, and the distribution plant is absolutely tight. The jointing of air pipes is exactly the same mechanical problem as the jointing of water or steam pipes, and tightness is as readily secured in the one as in the other. Several other speakers also defended air pipe lines, and one speaker said that electric transmission with electrically-driven air-compressor at the outer end can come into question only for distances exceeding five miles.

In the matter of crane service, Mr. H. M. Lane (Cleveland, O.), suggested that locomotive cranes deserve consideration in the foundry. Their usefulness in handling flasks to and from the outside storage is especially worth attention. The author agreed with this remark, and noted also that a locomotive crane is of much value in car shifting about a plant.

THE MICHIGAN STOVE CO. FOUNDRY.—A rather unusual type of foundry building was described by Messrs. W. J. Keep and E. Dwyer (Detroit, Mich.), in a paper entitled "A Foundry for Bench Work." The building in question replaces the foundry of the Michigan Stove Co. burned in January, 1907. The new foundry is 128 ft. square, 30 ft. high to the eaves, and 50 ft. high to the tops of the monitors. The brick walls are only 6 ft. high, the rest of the side being glass. The framework is steel, roof-trusses spaced 18 ft. being supported by side columns, and a line of central columns. The roof has a flat pitch and is of 2½-in. matched pine. Three monitors run across the roof. The floor is of brick laid in cement. One corner, 18 × 60 ft., is used for core room, and the rest of the area accommodates 86 bench molders. It is planned at a future time to put in an intermediate floor or gallery, with 12 ft. clearance above the ground floor, and 7 ft. clearance under the trusses; this would accommodate bench molders, and molding machines would be put under the gallery. The gallery would be kept 10 ft. away from the side walls, and would be made wide enough for one row of molders plus a gangway on the side toward the center of the building. However, this gallery was not built with the rest of the building, as bench work gives a greater molding capacity for a given floor-area. The foundry is heated by forced circulation of hot water at 157° F., 4,300 sq. ft. of radiating surface of 1½-in. pipe being provided, which are guaranteed to give 45° F. with zero weather outside.

THE VOLUMETRIC COMPOSITION OF CAST-IRON.—This descriptive paper was followed by "A Volumetric Study of Cast Iron," by Mr. H. M. Lane (Cleveland, O.). Essentially this was a demonstration of the fact that the impurities (or ingredients other than iron) in cast iron represent a very large proportion of the volume, if they are considered free, i. e., having the volume they would have if separated out as chemically free elements. While their proportion by weight is small, the volumetric proportion so calculated is many times as great. The lower strength of iron having high proportions of carbon, silicon, etc., is explained, according to the view which the author advanced, by the fact that the iron is spread out into a more open mesh-work, the interstices of which are occupied by the "impurities." This reasoning was suggested by a case where some small pieces of stove-plate had been left in a pickling tank for several months, accidentally. When discovered, these pieces still had their original shape and still looked like iron, but were exceedingly light. They were composed mainly of carbon, in very porous structure, and are supposed to represent the skeleton of "impurities" in the original iron, the pure iron having been dissolved out.

Mr. A. E. Outerbridge, Jr., reported a similar case. A pump suction strainer from a West Indian sugar and molasses steamer was found to have a specific gravity of 1.81 after some years of use, and chemical examination showed that there was little iron left in it. Another speaker cited the case of a line of cast-iron pipe (underground) carrying off acid sludge from an oil refinery, which during some excavation work was found to be so soft that a pick drove through it.

The author's argument from this observation was, however, strongly dissented from, especially by Mr. J. E. Johnson, Jr. (Glen Wilton, W. Va.) and Prof. Bradley Stoughton (New York City) on the ground that the elements other than iron are for the most part combined in the cast iron, with each other or with the iron, so that their aggregate volume is quite different from (less than) that calculated by the author. Prof. Stoughton showed slides of a large number of micro-photographs of steel and iron and pointed out from these the constancy of the several specific compounds which occur in the metal. The graphitic iron is the only part of the impurities which is not in combined form and which therefore probably has the relative volume attributed to it by the author. Mr. Johnson further argued against the author's statement that when carbon is burned out of iron a weakening by oxidation takes place, by remarking that in malleable iron the chief strength is in the outer layer, and this is totally decarbonized.

FOUNDRY TESTING.—A very clear-headed review of the present relation of the foundry to the practice of testing output and material was given by Mr. R. Moldenke (Watchung, N. J.) in a paper entitled "Specifications for Iron and Fuel, and Method of Testing Foundry Output." This paper, whose main points we will endeavor to present in abstract later, received no discussion.

THE CUPOLA AND IRON MIXTURES.—The next paper constituted a condensed review of the practical side of foundry metallurgy, embodying statements of good practice in cupola construction, in lining the cupola, in charging and handling the cupola, and in selecting and mixing iron for a melt. This was presented by Mr. W. J. Keep (Detroit, Mich.), under the title "Foundry Cupola and Iron Mixtures." It is not susceptible of abstracting, because of its detail character, but one fact stated by the author is worth noting, namely that the shape of the cupola interior is practically without influence on the melting efficiency. Results depend rather upon the skill or care of the melter. However, the author describes a special form, which has the lining contracted above the tuyeres, so as to give an overhanging bosh; the overhang is sloped back to a diameter 22 ins. larger, 2 ft. above the contraction. To produce this form, the lining is made 12 ins. thick in the hearth, 16 ins. at the contraction, and 5 ins. in the upper part of the furnace. Longer life of the lining, more rapid melting because the cupola can hold more iron, and slightly better melting ratio because of smaller bed of fuel, are claimed to result with this form. In the discussion, Prof. W. W. Bird (Worcester, Mass.), suggested that the crude selection of scrap by classifying into machinery scrap, stove-pipe scrap, etc., may be bettered by grading machinery scrap according to thickness, and noting whether it shows any evidences of machining; for a given class of machinery castings, then, scrap is to be approved if it has similar wall thicknesses and shows by the fact of previous machining that it is soft enough for working in the shop. The consideration of wall thickness of course enters because an iron soft enough for machining when cast in 1½-in. thicknesses may be too hard when cast in 1-in. thicknesses.

BLOWER PRACTICE.—Mr. W. B. Snow (Boston, Mass), gave a review of practice in another element of the foundry, in a paper entitled "Foundry Blower Practice." Much of it was devoted to a statement of the respective operating peculiarities of fan blowers and rotary pressure

blowers, and a comparison of their usefulness as cupola blowers. Characteristic curves of pressure, volume, and power with different gate openings and speeds were included in this part of the paper. The author presented argument to show that in selecting a fan blower it is important to select the proper volumetric capacity very closely as otherwise much power is wasted. He also argued in favor of large cupola diameters and large tuyere area, with lowered rate of melting per square foot of hearth area per hour, as giving greater economy and better metal. A few words on air-furnace practice close the paper; for these the author commends the trend toward lower pressure and larger volume of air supply.

Mr. S. A. Moss (Lynn, Mass.), remarked that the author's formula for discharge of air through orifices is correct only for very small pressure differences, and cannot be used above 2 oz. without correction for change of volume. A communication from Messrs. J. R. Fortune and H. S. Wells (Detroit, Mich.), described how a cupola was improved by enlarging the tuyere openings and decreasing the coke charges; the melting capacity per hour was thereby increased and the coke consumption per ton decreased. In reply to request for the test data on which the characteristic curves given in the paper were based, Mr. Snow explained that the curves are merely typical, not specific, and were intended to represent general relations. He also remarked that there is no uniform basis for testing blowers, and no systematic experimental study of these machines. No doubt very many tests of individual blowers have been made in the past year, in technical colleges and elsewhere, but being made without common plan they have no interrelation and do nothing to further our knowledge of blowers. The society, he declared, should take the matter up.

REQUIREMENTS IN PATTERN-MAKING.—"Patterns for Repetition Work," by Mr. E. H. Berry (Ilion, N. Y.), was a contribution on a subject little noticed by technical societies hitherto. Really it deals with patterns generally, Patterns for jobbing work rarely call for great accuracy, and are often extremely crude in finish on the theory that the molder can do the work more cheaply than the pattern-maker. But for repetition work patterns must generally be made up to the theoretical requirements, that is with all possible thoroughness and accuracy, so as to give maximum speed and efficiency of working in the foundry. What the author says, therefore applies for the most part to patterns generally, but may be neglected to greater or less extent in patterns which are to be used only once, or but rarely. The location of parting, the draft allowance, location of gates, etc., the material of the pattern, the method of carding, the grouping of patterns in the flask, the dimensions requiring accuracy, and other matters, are treated of at length, and with full illustration by practical examples. The author's experience in the Remington typewriter works enables him to speak with authority of repetition molding of small parts. A prominent recommendation made in his paper is that every pattern for such work should be made from a drawing showing the finished pattern and giving the actual dimensions of the pattern. The reasons for this are, first, that the pattern often looks quite unlike the casting, and the points of difference are chargeable to matters which are more properly determined in the designing room than in the pattern shop; second, that the shrinkage, finish and draft allowances make it a complex problem to determine the pattern dimensions from the dimensions of the casting, a problem which the pattern-maker should not be required to solve. Another recommendation, important because much neglected, is that the dimensions to and between unfinished surfaces should receive first attention, since they determine the shape and clearances of the casting, while the finished surfaces can easily make up for variations by variation in the machining. The great number of more detailed comments composing the paper can unfortunately not be abstracted here.

In discussion, Mr. E. H. Mumford pointed out that when patterns are put alternately on opposite sides of a plate or card, they may in many cases be arranged so that their edges are in actual contact, which saves the sand-space between them and thus increases the capacity of a given size of flask. Mr. H. M. Lane noted that the Westinghouse Machine Co. and the Becker-Brainerd Milling Machine Co. have for some time made use of drawings for patterns and pattern rigging, the latter concern resorting to this method at a time when they placed a lot of work on molding machines. Mr. Berry finally added to his paper an important remark, namely that the plan of designing patterns fully in the drafting-room is successful only when there is very complete co-operation and consultation between drafting-room, foundry, and the foremen of the various departments who must use the castings. To instance a single point for which such consultation is required: The gating of the patterns must, besides being uniform, be so located that the roughness or projection likely to be left at the gate will not interfere with placing the casting in the jigs by which it is machined.

After the discussion of this paper, it was moved (by Mr. H. M. Lane) to refer to the Council the question of the advisability of appointing a committee to consider standards for pattern details and associated foundry equipment (flask sizes, etc.). The motion was carried.

LIMITATIONS OF MOLDING MACHINES.—The last of the papers on Foundry Practice was presented by Mr. E. H. Mumford (Philadelphia, Pa.); this was "Some Limitations of Molding Machines." The title of this paper is adequately descriptive. The author puts into words many of the obstacles to success in molding by machine, and makes rather more clear than has hitherto been done in writing that any attempt to reduce molding to an automatic-machine process is foredoomed to failure. In conclusion, he extols recent French development of molding machines as being nearest to perfection than anything worked out elsewhere.

In addition to the papers on the two main subjects, two papers of totally different character were presented.

THE APPRENTICE SYSTEM OF THE NEW YORK CENTRAL LINES.—Mr. W. B. Russell, of New York City, described the apprentice system that was instituted on March 1, 1906, by Mr. J. F. Deems, General Superintendent of Motive Power, and now in operation at the nine larger shops of the New York Central System. There are about 500 apprentices enrolled. A shop instructor teaches the "trade" side of the course. This instructor is preferably an all-around machinist but with a good knowledge of the other trades. In a small shop he is to devote only a part of his time while in a larger one his entire time may be required and he may have assistants. He is invested with sufficient authority to command respect, co-operation, good will and confidence of all.

The "educational" side of the course is given by an instructor who may be a draftsman, an advanced mechanic or a mechanical engineer. This instructor is to spend only a part of his time in teaching and is to retain a position in the shop or drafting room. If the teaching duties become heavy, assistants may be required to maintain this division of the instructor's work.

All of the trade work done by the apprentices is a part of the regular shop work. Class room instruction is largely individual and is based on actual shop problems. Mechanical drawing is the basis of this course. In the mathematical problems the classifications into algebra, arithmetic and the other divisions are not made, as such. The problems are usually so mixed with the practical applications of natural laws, and useful data that they do not appear as mere mathematical problems.

The immediate results attained were stated to be

increased output (notwithstanding the 4 hrs. per day spent in class); less spoiled work; ability to read drawings, to lay out templates and to make sketches; a better grade of apprentices; increased interest in the work; suggestions of apprentices as to improved methods and tools; draftsmen for company drafting rooms; apprentices for special work as needed. Local officials have been quick to note the benefits of apprentice training and are unanimously enthusiastic and interested. One immediate result of the opening of the apprentice schools was the request of foremen and mechanics for classes of a similar nature. This has resulted in the organization of self-supporting evening classes, seven of the shops, taught by the apprentice instructors and using practically the same courses of study as provided for apprentices.

POWER TRANSMISSION BY FRICTION DRIVING.—This paper by Professor W. F. M. Goss, University of Illinois, contained the results of an extension of a previous study embodied in a paper presented to the society in Dec., 1896 (see Engineering News, Jan. 21, 1897). The friction drive was taken to consist of a driving wheel having a somewhat elastic contact surface and working in rolling contract with a metallic surfaced driven wheel. The power which may be transmitted was shown to be dependent on the pressure of contact and the coefficient of friction between the surfaces of the wheels. The experiments outlined were undertaken to derive numerical values for these factors and to derive formulas, tables and diagrams making such numerical factors of immediate use particularly to machine designers. The fibrous materials used on the driving wheels were such as straw-fiber, leather, leather fiber, sulphite fiber and tarred fiber. Each of these materials as driving surface was tested with driven wheels of iron, aluminum and type metal.

RULES OF THE NEW YORK PUBLIC SERVICE COMMISSION FOR TESTING LOCOMOTIVE BOILER STAY BOLTS.

A portion of the rules for locomotive-boiler inspection, issued in August of this year by the Public Service Commission of the State of New York, Second District, covers the testing of stay bolts. We reprint these rules here, believing that, in view of existing differences of opinion on the subject of stay-bolt testing, they will interest our readers.*

STAY-BOLT TESTING.

(a) TIME OF TESTING RIGID BOLTS.—All stay bolts should be tested at least once every month, and no boiler must be used over 3 months under any circumstances unless thorough stay-bolt inspection has been made. Stay bolts shall also be tested immediately after every hydrostatic test.

(b) METHOD OF TESTING RIGID BOLTS.—The inspector must take each bolt from the fire-box side and judge from the sound or the vibration of the sheet which of them are broken. If stay-bolt tests are made when the boiler is filled with water, there must be no less than 50 lbs. pressure on the boiler. This will produce sufficient strain upon the stay bolts to cause the separation of the parts of the broken ones. Should the boiler not be under pressure the tests may be made after draining all the water from the boiler, in which case the vibration of the sheet will indicate any unsoundness. The latter test is preferable.

(c) METHOD OF TESTING FLEXIBLE STAY BOLTS.—All flexible stay bolts having caps over the outer ends shall have the caps removed at least once every year, and also whenever the inspector considers the removal desirable in order thoroughly to inspect the stay bolts. The fire-box sheets should be examined carefully at least once a month to detect any bulging or indications of broken stay bolts.

(d) BROKEN STAY BOLTS.—No boiler must be allowed to remain in service when there are two adjacent stay bolts broken in any part of the fire-box or combustion chamber, nor when three or more are broken in a circle 4 ft. in diameter.

(e) TELL-TALE HOLES.—All stay bolts shorter than 8 ins., applied after Sept. 1, 1907 (except flexible bolts), shall have tell-tale holes $^5/_{16}$-in. in diameter by 1¼ ins. deep or more in the outer end. These holes must be kept open at all times, and must not in any case be plugged. All stay bolts shorter than 8 ins., except flexible bolts, shall be drilled when the locomotive is in the shop for heavy repairs or at other suitable opportunity, and this work must be completed prior to Jan. 1, 1909.†

*The full text of the Commission's rules for testing locomotive boilers may be obtained by addressing Mr. J. S. Kennedy, Secretary, New York Public Service Commission, Second District, at Albany.

†Applications from companies desiring to omit the use of tell-tale holes will be considered when it can be shown to the satisfaction of the commission that unusual care is used in stay-bolt testing, both as to the frequency of tests and the selection of inspectors.

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One week ago we commented in this place on the lack of state legislation securing the safety of mine operatives and we contrasted our American policy with the stringent regulations enacted by British lawmakers to protect the Kaffirs and Chinese at work in the Transvaal mines.

Since our last week's note was written, two terrible mine disasters have occurred in this country, one at Naomi, Pa., costing the lives of 34 miners, and the other at Monongah, W. Va., where the number of victims is still unknown, but is expected to exceed 500, so that it will rank as one of the greatest mine disasters on record.

Each of these disasters was due to an explosion, and the newspapers give various reports as to what caused the explosion, according to the knowledge—or lack of knowledge—of the reporter. We know nothing as to what precautions may have been in use in these mines to guard against explosions, and nothing of course as to what degree of blame for the disaster may properly be placed on the mining companies involved or their officials. What we do know is that the causes of mine explosions and the precautions necessary to avoid them have been well known to competent mining engineers for a score of years and more. The use of explosives producing little flame, thorough wetting of the vicinity of a blast before setting it off to prevent a blown-out shot starting a dust explosion, keeping naked lights away from the vicinity of a new blast, where large volumes of gas may be escaping—these are among the well known safeguards in common use.

We cannot say what precautions were neglected to bring about these two recent catastrophes; nor do we know whether the neglect was due to any carelessness on the part of the company or its officers or to poor discipline among employees who may have failed to observe prescribed precautions. This we can say, however: that the safeguarding of life under such conditions of danger as those made evident by these great disasters ought by no means to be left to the pleasure of the mining companies. If it is right to enact legislation safeguarding the lives and limbs and health of workmen in factories, or on railways, it is at least equally important to ensure some limited measure of protection to the men who dig from the depths of the earth the coal on which our modern civilized life depends.

Further, every such great disaster ought to be an object lesson to warn other mining companies and other miners of the dire necessity of precautions in their dangerous calling. The circumstances of the disaster should be made clear so that similar disasters may be better guarded against in the future. We see no means of reaching this end save by a Government investigation of all such disasters. Such investigations are made as a matter of course in every other civilized country and it ought to be possible in some way to provide for them here.

When an engineering structure fails, one hears almost invariably that a number of people knew all along that something was seriously wrong. The design and construction are subject to searching criticism, and every slightest variation from ordinary practice is seized upon and magnified until the controlling causes of the disaster and the real lessons to be drawn from it are often obscured.

So long as a bridge or a building continues to stand and show no sign of distress, however, few are bold enough to venture upon public criticism. The mere fact of its standing outweighs in the public mind any theoretical arguments against its stability. Further, even though an engineer may be positive that a structure is unsafe, he will seldom venture to predict that actual collapse will occur. The behavior of material stressed near the breaking point is very uncertain.

On the other hand, there is often as much to be learned from a structure which transgresses accepted rules of design and still stands up as from one which falls down. Conservative engineers test specimens of their materials in machines until fracture occurs, and compute from the data thus obtained the safe working loads. It is desirable, however, to supplement such data with actual trial of full-sized specimens, or what is better yet, to build actual structures and overload them and observe what occurs. Conservative engineers will not venture to use their clients' money in the latter way, but when someone through ignorance or overboldness does "go the limit" in his constructive work, it is well worth while to watch its progress and note the final result.

We give considerable space in this issue to a description of a reinforced-concrete garage on Coney Island, New York City, which is worth study for the reasons above set forth; and for convenient comparison with it we have also described another recently built concrete garage near New York having roof girders of very similar span. The contrast between the two designs is striking. In the one we find roof girders of 72-ft. span, 12 × 36 ins., in cross-section, and reinforced with 14 sq. ins. of metal. In the other we have a roof girder of 75-ft. span, 18 × 75 ins. in cross-section, and reinforced with 25 sq. ins. of metal. This latter girder was carefully designed and corresponds closely to general good practice in reinforced-concrete design.

To find what unit stresses the former structure is imposing upon the concrete and steel of which it is made, we have secured an expert report upon it, from the late Chief Engineer of the New York Building Department. The report speaks for itself; but it may be noted here that nearly every member of the roof has a stress in excess of that permitted by the Building Law, and that under the most favorable assumptions the concrete in the long hip girders above referred to is carrying a load of 1,100 lbs. per sq. in. This figure is reached, moreover, by assuming that a T-beam action occurs at the hip, an assumption which is not warranted by the angular joint which the slab makes at this point or by the method of disconnected construction. To sustain so high a stress, which is evidently lower than the actual amount, the very best and strongest mixture of concrete would have been none too good. But instead a 1:2:5 mixture, which under the most favorable circumstances could hardly run higher than 2,500 lbs. per sq. in. in a 30-day test, was put in with practically no inspection.

Yet the building stands up, and despite a lot of threatening cracks in the roof system, it may stand for long years to come. Its standing, however, cannot make it safe. No man is wise enough to say at what moment some of those untoward circumstances which engineers provide for with a safety factor may add the last straw that will break the backbone, and convert the automobiles stored beneath this heavy roof into a mass of scrap.

What we desire particularly to emphasize is that such a collapse, when it comes, will be no more an argument against reinforced-concrete construction than a broken axle on an overloaded wagon is an argument against the use of wagons. Plenty of people are taking liberties with reinforced concrete. Structures built of it have gone down in the past, and others will go down in the future; but where such disasters are shown to be due to defective design or construction there is no ground for bringing such occurrences forward as an argument against concrete as a building material.

FIFTY MILLIONS A YEAR FOR WATERWAY IMPROVEMENT: WHERE SHOULD IT BE SPENT?

There assembled at Washington last week 2,000 delegates representing 32 different states, to attend the convention of the National Rivers and Harbors Congress. As our readers are aware, waterway conventions have been held in different parts of the country during the past few months, notably one at Philadelphia to agitate for an interior water route along the Atlantic coast and one at Memphis in the early fall to advocate a deep waterway from the Lakes to the Gulf. The convention at Washington last week was assembled to consider not the project of any one section but the general policy which the Government ought to pursue toward waterway improvement.

The net result of last week's convention was the adoption of resolutions recommending that at least $50,000,000 a year be spent by the Government on the improvement of the country's waterways. We say this was the net result; but a result much more important than the formal resolutions adopted was the effect on public opinion. There can be no doubt that this convention and the similar local conventions which have preceded it have aroused and educated public opinion on the question of waterway improvement to an extent hitherto unknown, and this public opinion will be reflected in legislation. Unless we are altogether mistaken, Congress will in the future regard the work of waterway improvement very differently from what it has in the past.

The old idea was that a River and Harbor bill was so much "pork," to be apportioned among all the Congressmen so that each could go home and tell his constituents how much Government money he had secured to be spent in the district. The natural result of that old idea was to spread waterway expenditures over a multitude of projects, most of them meritorious enough indeed, but wholly disconnected and unrelated to each other. It was nobody's particular business to see that the expenditure for waterways as a whole was so directed as to secure large results and create great through routes.

Of course this old idea of River and Harbor appropriations has been gradually fading away. There has been a great measure of reform, particularly since the "continuing contract" system of appropriations was adopted by Congress. Many of the works which have been carried out, such as those on the Great Lake channels, the improvement of the Gulf ports and the work on the Ohio and Mississippi rivers, has been of immense value to the nation as a whole, as well as to the localities immediately benefited. In the future, however, we believe greater emphasis will be laid on such works of national importance. Congress is likely to study waterway improvement from the national and not the sectional point of view; and the additional appropriations which may certainly be expected are

likely to be devoted to the great works, rather than to an increase in the number of smaller projects, benefiting limited localities.

In the year ending June 30 last, the Government spent in round figures 23½ million dollars on River and Harbor improvements. The Chief of Engineers, in his annual report just issued, recommends appropriations of some 27½ million dollars for the year ending June 30, 1909. The 50 million dollars annual average recommended by the recent convention, therefore, would substantially double the present rate of Government expenditure on waterways.

In studying the broad question how this sum should be spent in order to secure the greatest advantage, it is of interest to examine the speeches delivered at last week's convention. The keynote of these speeches was the need for waterways to relieve the congestion of present transportation facilities. The railways, it was urged, are carrying all the traffic they can handle and find themselves unable to increase their tracks and terminals fast enough to cope with the freight that is pressing upon them.

But when we analyze this statement, we find that it is not our entire railway mileage that suffers from congested traffic but only the comparatively small mileage of through trunk lines, connecting the different sections of the country. If waterways are to be built to relieve traffic congestion, therefore, the aim should be to create great through water routes. Such waterways will be of value to the nation as a whole, as well as to the particular section in which they may be located. The convention last week wisely specified in its resolutions that such waterways should be improved as would justify the work "by present and prospective benefits to commerce." This again points to the selection of great traffic routes for improvement. It is on such routes only that a large volume of traffic will be secured and only by carrying a large tonnage can the proposed waterway improvements yield a public benefit commensurate with their cost.

It may fairly be assumed that the present rate of River and Harbor appropriations will provide for continuing at a satisfactory pace, the class of works already undertaken. The additional $25,000,000 a year, then, ought to be chiefly if not wholly devoted to the works of largest importance—to the improvement of waterways whose benefits will be national in scope.

Holding first place in the public attention as national waterways, are the Mississippi and Ohio rivers, extending from the Gulf to Pittsburg on the east and to St. Paul on the north. Many millions have already been spent by the Government on these streams and their principal tributaries. Their further improvement should be conducted with a view to utilizing so far as possible what has already been done, and also with a view to the operation of the system as a whole. That is to say, money should not be concentrated to secure great depths at one part of the system if that depth cannot eventually be carried through the entire system.

In fixing the depth to be aimed at for this Western river system, moreover, it must be remembered that great depth is not necessary to secure low cost of transportation. The close relation between depth of draft and transportation cost that obtains with vessels for use on the ocean or the Great Lakes does not obtain on inland river steamers. Some of the cheapest water transportation in the world has been done on the Ohio and Mississippi rivers in their present condition. The actual depth of the water in a river is of far less importance to steamboat men than the certainty that the depth will be maintained. A reliable depth of 12 ft. in the Western river system would be far better than a nominal depth of 15 to 16 ft. attained only with such difficulty that frequent shoaling would occur.

All will agree on the eminent desirability of connecting the Ohio and Mississippi waterway system with the Great Lakes, either by the Illinois River route from St. Louis to Chicago or by a connection between the upper Ohio and Lake Erie; or very probably by both. Thorough investigation of both routes is certain to be made, but it may be premised that such connections would be used by vessels of the river system, and not by the lake steamers, hence the draft of the former and not the latter should govern.

And now if we imagine the Ohio and Mississippi systems improved and connected with the Great Lake system by one or two links, there would still remain one waterway lacking to complete the beneficent work. That waterway is a connection of the Great Lakes with the Atlantic seaboard, a connection whose need has been recognized for more than a score of years. Today there is no waterway in the world, the Suez or the Panama Canal not excepted, which could command such a volume of traffic. If the nation is really to spend $25,000,000 additional a year on waterway improvement, it can spend no part of it anywhere with a greater resultant measure of public benefit than on the construction of this waterway.

As our older readers at least will recall, the Lakes and Atlantic Deep Waterway is no new project. In the early '90's great conventions were held in the central West to advocate its construction. In response to the public sentiment awakened by these conventions, Congress created a commission which made preliminary investigations and advocated the enterprise in the strongest terms. A second commission of engineers was created in 1897, which spent three years' time and half a million dollars in making complete surveys and detailed estimates for a waterway from Lake Erie to New York City, via Lake Ontario, the Oswego, Mohawk and Hudson rivers. This waterway was to have a depth of 21 ft., sufficient for any vessel now navigating the Great Lakes; and the estimated time of transit from Buffalo to New York City by such a waterway is *less than three days.*

No engineering enterprise projected by the United States was ever more carefully and scientifically investigated, and few, if any, ever promised a vaster measure of public benefit. That it was not undertaken by the Federal Government after the surveys were completed, was due, we believe, to the fact that certain powerful interests which would be adversely affected by such a waterway exerted their influence to have it quietly dropped. Notwithstanding the strong report of the two commissions of high standing urging the construction of the work, nothing further has ever been done by Congress.

Meanwhile the State of New York, after more than a dozen years of preliminary discussion and investigations has undertaken to build a 1,000-ton barge canal extending from Lake Erie to the Hudson River, following the general route of the old Erie Canal. Contracts have been let for a part of this work and the remainder are expected to be let so that the whole work will be put under contract by October, 1908.

Engineering News has always opposed this New York barge canal as an enterprise planned on too small a scale to suit economic demands. If the New York barge canal is completed as now planned, it will be a waterway requiring transshipment of all cargo at New York and at Buffalo. In fact there is every reason to believe that the canal was deliberately planned to be of small size to make such transshipment necessary.

We believe it is not too late for the Federal Government to step in and itself assume the work of providing an adequate waterway from the Great Lakes to the Atlantic; and the step should be taken at once, at the present session of Congress, before the State of New York proceeds farther with its barge canal. If Congress does not do this now, then it must be done at some future day and at greatly enhanced cost.

It would be absurd for the Federal Government to create a great system of national waterways in the Mississippi Valley and Great Lakes basin and provide no better waterway to connect the system with the Atlantic seaboard than an inadequate barge canal, and that under state control and with traffic through it subject to such tolls as the state may impose.

Emphasis should be placed, also, on the vast range of territory which a deep waterway accommodating lake shipping would benefit. The Lake vessels passing through the canal would not necessarily stop at New York to discharge or take on cargo, but could ply up and down the coast from Portland on the north to Savannah on the south. Recently a largely attended convention at Philadelphia waxed enthusiastic over a projected inland waterway paralleling the Atlantic Ocean, extending from Boston to Beaufort. We shall not here discuss the arguments for and against such an enterprise, but it is safe to say that a deep waterway from the Lakes to the Atlantic coast would benefit the states bordering the coast ten times as much as the inland water route referred to.

New York State would reap so much larger benefit than can possibly accrue from the small work it now has under way, that it could well afford to contribute the hundred million dollars it has already voted for that work, if it would ensure the nation's undertaking the larger task.

At the other end of the route the benefits would be even more widely distributed. Through transit without breaking bulk between the Lake ports and tidewater would mean cheaper transportation and consequent higher prices for all the exported products of the West as well as those marketed in the great centers of population in the Atlantic States. In the return direction the cheaper transportation would mean lower prices to consumers of eastern manufactures throughout the great territory tributary to the Lakes and the Mississippi.

If waterways are to be built to relieve congestion of freight traffic, then assuredly nowhere in the United States can such effective relief be afforded by waterway construction as by this deep waterway to the Atlantic.

It is true that Canada has already in operation a through waterway from the Lakes to the Atlantic via the Welland and St. Lawrence canals which can accommodate vessels up to 2,000 tons displacement; but this is inadequate for the modern lake steamers. It is true also that Canada has made complete surveys and estimates for a 21-ft. deep waterway from Lake Huron to tidewater via the Ottawa River, and is very likely to undertake and carry out this work. Neither of these Canadian water routes, however, offer a short and direct route to the great markets of the Atlantic coast like the route through central New York. Even for export trade the Canadian routes must always have the great handicap of perilous navigation in the lower St. Lawrence and on the dangerous coasts leading to it, a fact brought forcibly to mind by the recent wreck of a Canadian Pacific steamer with 600 passengers on the Nova Scotia coast.

It is well worth while for the United States to make its own waterway through its own territory to bring the Lake vessels to tidewater. The total cost of such a waterway was estimated by the Raymond-Noble-Wisner Commission seven years ago at $200,000,000, in round numbers. If New York would contribute the $100,000,000 it is proposing to spend on its barge canal toward the greater enterprise the net cost to the nation would be only $100,000,000; and surely nowhere else could a work of waterway improvement be undertaken promising so vast a measure of public benefit in proportion to the cost.

LETTERS TO THE EDITOR.

Prepayment ("Pay-As-You-Enter") Cars.

Sir: In your issue of November 21st, I notice your reference to the introduction of the "Pay-as-you-enter" cars on New York City street car lines. The car though not yet perfect by any means, is a very welcome idea and its advantages over the antiquated type will undoubtedly manifest themselves in due course, but, why apply such a clumsy, ungainly name to them? Webster says that to "pay in advance or beforehand" is "prepayment." These conveyances are nothing more or less than prepayment cars whereby we pay for service in advance or beforehand as we pay for gas or electric lighting service by the medium of the prepayment meter.

This seems a propitious time to give the cars their simple and appropriate name. Have some sympathy

with the posterity that will have to wrestle with such an awful name as "Pay-as-you-enter."

The car is a Montreal production, but the idiot who thus christened it is still undiscovered.

Trusting you will do your part, I remain,

Yours very truly,

J. J. Cagney.

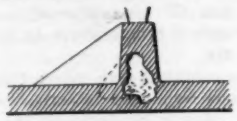
Montreal Light, Heat & Power Co.

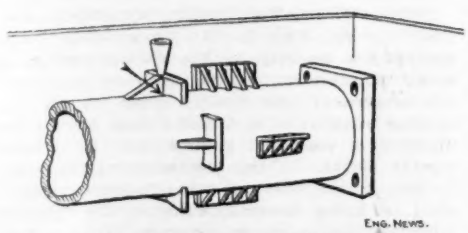
Montreal, Canada, Nov. 27, 1907.

A Dangerous Spot in Cast-Iron Columns.

Sir: A description of a fault found in large cast-iron columns that very easily escapes detection may be of interest to inspectors of iron work.

A number of columns 14 ins. in diameter, 2-in. metal, 14 ft. 10 ins. long, with four brackets and lugs, were poured and let cool in the usual way, with a riser from the uppermost bracket. They came from the foundry in apparently sound condition, but when a chisel was tried at the base of the bracket that had been uppermost in the sand, the whole base caved in and revealed the fact that the metal of the bracket next the column was a mere shell. The cavity was due to the





ENG. NEWS.

A Defective Bracket of a Cast-Iron Column.

contraction of the iron in the columns while cooling, allowing the still molten interior to flow away after the outer shell had set. The defect was remedied in all following columns by churning the metal in the riser while it cooled. This trouble seems to be quite general in columns of this size and requires special attention.

Yours very truly,

F. L. Martindale.

2324 Harney St., Omaha, Neb., Nov. 14, 1907.

[Reference to the report on the failure of the Brown soap factory in New York City, Eng. News, June 17, 1897, p. 373, and to the report of tests of brackets on cast-iron columns at Phoenixville for the New York City Department of buildings, Eng. News, Jan. 20, 1898, p. 36, will show that similar though less serious defects at the connection of bracket and column have been repeatedly pointed out. It should be noted that the Phoenixville tests of the strength of brackets showed very low values, although the fractures showed no defects approaching in seriousness the one above described.—Ed.]

Stresses in Column Lattice.

Sir: In an article in Engineering News of Nov. 7, entitled "The Lacing of Compression Members," by C. T. Morris, Assoc. M. Am. Soc. C. E., it is assumed that, in a column composed of two leaves latticed together, the total amount of stress to be transferred by the latticing is equal to the difference between the permissible unit-stress in compression for short pieces and the average permissible unit-stress obtained by column formula, multiplied by one-half the area of column. This would imply that the unit-stress for the whole leaf was equal to that at its outer fibers. Is this correct? To the writer, it seems more reasonable to assume that the total amount of stress to be transferred by the latticing is equal to the difference between the unit-stress at the center of gravity of either leaf and the average permissible unit-stress obtained by column formula, multiplied by one-half the area of column, the maximum outer fiber stress being equal to that allowed for short pieces in compression as before.

Let l = total length of column.
A = total area of cross-section.
r = radius of gyration.
x = distance from center of gravity of section to center of gravity of either leaf.
n = distance from center of gravity of section to outer fibers.
s_1 = maximum allowed unit-stress in compression on short pieces.
s_c = average allowed unit-stress on column, from a column formula.
V = total amount of stress transferred by latticing.
v = increment of stress per unit of length.

Then $V = \frac{A}{2}(s_1 - s_c)\frac{x}{n}$; and, for square ended column,

$$v = \frac{\frac{A}{2}(s_1 - s_c)\frac{x}{n}}{\frac{1}{4}l} = \frac{2A(s_1 - s_c)\frac{x}{n}}{l}.$$

With the straight-line formula, $s_c = s_1 - c\frac{l}{r}$; then

$$v = \left(\frac{2cA}{r}\right)\left(\frac{x}{n}\right)$$

Now, taking the given example of a column composed of two 15-in. 33-lb. channels latticed together, toes out, 9.5 ins. back to back,

$A = 19.8$ sq. ins.
$r = 5.62$ ins.
$s_c = 16{,}000 - 70\frac{l}{r}$
$x = 5.54$ ins.
$n = 8.25$ ins.

Then $v = \frac{2 \times 70 \times 19.8}{5.62} \times \frac{5.54}{8.25} = 325$ lbs. per lin. in.

instead of 494 lbs. per lin. in., as given by Mr. Morris.

Yours truly,

W. Chase Thomson, M. Can. Soc. C. E.

Montreal, P. Q., Nov. 21, 1907.

The Strength of Corrugated Sheeting.

Sir: In your issue of Nov. 14, Mr. Thos. C. J. Bailey, Jr., replying to the inquiry of Mr. F. L. Burr, which appeared in your Oct. 4 number, regarding the strength of corrugated steel, refers to a formula on p. 230 of Ketchum's "Steel Mill Buildings," which is said to be based on Rankine, for the strength of a corrugated sheet considered as a simple beam. The formula given is as follows:

$$W = \frac{4}{15}\frac{S h b t}{l}.$$

Where W = total safe load uniformly distributed, in lbs.
S = working stress, in lbs. per sq. in.
h = depth of corrugations, in ins.
b = width of sheet, in ins.
t = thickness of metal, in ins.
l = clear span, in ins.

There is, however, a lack of agreement between the loads as derived from this formula and those obtained from the diagram showing safe loads per sq. ft. which appears at the bottom of the same page in Ketchum's "Steel Mill Buildings." For instance, take a No. 20 gage sheet, 2 ft. wide on a 5-ft. span. The thickness of the sheet is $^3/_{80}$-in., and assuming depth of corrugations to be $\frac{5}{8}$-in. and an allowable stress of 15,000 lbs. per sq. in., the total safe uniformly distributed load as found from the preceding formula would be

$$W = \frac{4}{15}\frac{15{,}000 \times \frac{5}{8} \times 24 \times {}^3/_{80}}{60} = 37.5 \text{ lbs.}$$

As the area of the sheet is 10 sq. ft., this result would indicate a safe load of only $3\frac{3}{4}$ lbs. per sq. ft. The diagram, however, shows a safe load of 24 lbs. per sq. ft. for the same conditions. The latter is evidently nearer correct, as it agrees closely with the general use made of corrugated steel for roof coverings and similar purposes.

In Rankine's "Civil Engineering," on p. 543, it is stated that the *breaking moment* of corrugated sheets, using the previous notation, is approximately

$$M = \frac{4}{15} S h b t \quad \ldots\ldots\ldots\ldots\ldots\ldots (1),$$

from which it follows for uniform load that

$$\frac{W l}{8} = \frac{4}{15} S h b t,$$

and

$$W = \frac{32}{15}\frac{S h b t}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2).$$

The Rankine formula is derived from the moment of inertia on the assumption that the curves of the corrugated sheets are cycloidal arcs. (See Greene's Notes on Rankine's Civil Engineering, p. 108, where a demonstration is given of the derivation of this formula.) The Rankine formula is approximate only in the sense that the curves are assumed so flat that their lengths can be taken the same as their chords. In corrugated iron, as now manufactured, the length of the arc is 1.172 times the chord. Making this correction, the Rankine formula becomes

$$W = \frac{37\frac{1}{2}}{15}\frac{S h b t}{l} = \frac{5}{2}\frac{S h b t}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3).$$

If the stress at the crippling strength of the sheet is taken at 40,000 lbs. per sq. in., the formula for total uniformly distributed load at failure becomes

$$W = \frac{100{,}000 h b t}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4),$$

which is practically the formula given originally by Mr. C. L. Strobel in the Carnegie handbook. For a nominal factor of safety of 4, the safe uniformly distributed load on a given sheet may be written:

$$W = \frac{25{,}000 h b t}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5).$$

The latter is the formula given by the writer, ten years ago, in the Passaic handbook for the total safe uniformly distributed loads on corrugated sheets. He has seen no reason to change the formula, as it gives results agreeing with experience and with the best practice in the use of corrugated sheets for supporting roof loads, and has therefore incorporated the same formula in the new Bethlehem Steel Co. handbook, just issued.

If the safe load per sq. ft. is desired, it is found from the formula:

$$w = \frac{25{,}000 h t}{L^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6),$$

where w = safe load in lbs. per sq. ft.
L = length of span, in ft.

This latter formula corresponds to a safe fiber-stress of 10,000 lbs. per sq. in. It is curious to note that it gives results practically identical with those given by the diagram at the bottom of p. 230 of Ketchum's "Steel Mill Buildings," though the latter is stated to be based on a fiber-stress of 15,000 lbs. per sq. in.

Safe Load per Sq. Ft. on No. 20 Corrugated Iron.

Span, in ft.	From Ketchum's diagram.	From Formula (6).
2½	92	93.7
3	65	65.1
4	36	36.6
5	24	23.4
6	16	16.3

This diagram is incorporated in the general specifications on p. 399 of Ketchum's "Steel Mill Buildings" as a guide for the spacing of purlins. It gives results practically identical with those obtained from the so-called "Carnegie" formula when a factor of safety of 4 is used.

George H. Blakeley.

South Bethlehem, Pa., Nov. 25, 1907.

ANNUAL MEETING OF THE NATIONAL RIVERS AND HARBORS CONGRESS.

A largely-attended convention was held last week at Washington to urge greater activity by the Federal Government in the work of waterway improvement. Addresses were made before the congress by Secretary Root, Ambassador Jusserand of France, Representative Barton, for many years Chairman of the House Committee on Rivers and Harbors, Senator Newlands, Vice-President of the Inland Waterways Commission, Jas. J. Hill, Geo. Clinton, Gustav H. Schwab and others. A delegation from the convention called on Vice-President Fairbanks and Speaker Cannon to present the resolutions adopted for transmission to Congress and were assured by both these officials that they would support the policy of waterway improvements.

The formal resolutions adopted by the convention and the officers elected at the closing session are printed below:

After a year's consideration of the aims and purposes of the National Rivers and Harbors Congress, as expressed in the resolutions adopted by that body in 1906, the American people have given them emphatic indorsement by sending to this convention, assembled at the national capital December 4, 5 and 6, 1907, nearly 2,000 delegates from thirty-seven states and territories, representing the commercial, manufacturing, producing and consuming interests of the country, and these delegates are unanimously of the belief:

First—That profitable and successful commerce is absolutely dependent upon economical transportation of commodities, and that the importance of transportation will increase with the growth of population and the development of the nation's resources.

Second—That the railroads of the United States are now unable to handle the business offered them, and much loss results from the congested condition of traffic; that, according to high railroad authority, the business of the country has increased over 100 per cent. within ten years, while the facilities for handling it by rail have been increased only about 20 per cent., and, as the railroads cannot be expected in the near future to increase their facilities sufficiently to relieve the situation, other means of transportation should be provided at once.

Third—That transportation of heavy commodities by water on all rivers and inland waterways is much cheaper and usually quicker than by rail; that no country in the world has been so blessed by nature with water courses as our own, and that if properly improved and connected by canals, they would furnish a convenient, quick and cheap means of shipping enormous volumes of freight.

Fourth—That the time has come when the policy of the Federal Government toward waterways, over which it rightly has supreme control, should be more liberal, persistent and continuous than heretofore; that appro-

priations for rivers, waterways and harbors have been made at intervals of three years instead of annually; that for the last ten years they have averaged only about $22,000,000 a year, or less than 3 per cent. of the average annual expenditures of the government, and that enough money should be appropriated each year for at least the next ten years to properly improve the various rivers, waterways and harbors.

Therefore, be it resolved by the National Rivers and Harbors Congress, at the present session, containing delegates of every shade of opinion, and representing every business interest in the land, standing for a policy, not for a project:

First—That we earnestly urge the adoption by the Federal Government of a wise, liberal and comprehensive waterway policy that will provide for the proper improvement, within the next ten years, of the rivers, waterways and harbors of our country, the improvement of which is justified by present and prospective benefits to commerce.

Second—That without presuming to prescribe the engineering or the financial details of this great undertaking, this congress strongly urges upon the Congress of the United States the importance of the immediate adoption of a comprehensive plan of waterway improvement, of the carrying on of the work by an adequate number of engineers, and of such liberal appropriations annually as will insure the early completion of such projects as may be undertaken.

Third—That we cordially indorse the action of President Roosevelt in appointing a special inland waterways commission, being confident that its report will prove a source of accurate and valuable information to the American people. We further recommend that Congress enact such laws as will make the Inland Waterways Commission permanent.

Fourth—That this congress cordially thanks President Roosevelt for the support he has given to its purposes by his speeches and by his treatment of the subject in his recent message to Congress.

Fifth—That we ask Congress to view the river and waterway and harbor appropriations not as the appropriation of money for the current expenses of government, but as an investment in permanent improvements, bound to pay increasing dividends from year to year. Congress is fully warranted in authorizing an annual expenditure, beginning at the present session, of not less than one-tenth of the amount of money required for all the various river, waterway and harbor improvements already planned and approved by the engineers in charge or hereafter planned and approved, in order that the work may be carried to speedy completion, such appropriation to be not less than $50,000,000 annually, and Congress is further warranted in authorizing the expenditure of the money as needed, and in providing for the same, if in excess of funds available, by a bond issue similar in character to that for the building of the Panama Canal, whereby part of the cost of these improvements will be spread over a succession of years and borne by all who share the benefits.

The congress elected these officers:

President, Joseph E. Ransdell, Louisiana; secretary-treasurer, J. F. Ellison, Cincinnati, Ohio.

Directors.—Atlantic Seaboard—William H. Lincoln, Boston; Olin J. Stephens, New York; J. Hampton Moore, Philadelphia; Frank D. La Lanne, Philadelphia; F. W. Wood, Baltimore.

South Atlantic Seaboard.—E. J. Hale, Fayetteville, N. C.; L. D. Dozier, Columbia, S. C.; W. B. Stilwell, Savannah, Ga.

Gulf Seaboard.—T. G. Bush, Birmingham; M. J. Sanders, New Orleans; S. Taliaferro, Houston; S. W. S. Duncan, Dallas, Texas.

Mississippi Valley.—Gov. J. A. Johnson, St. Paul; Thomas M. Wilkinson, Burlington, Iowa; W. P. Kennett, St. Louis; W. K. Kavanaugh, St. Louis; Charles Scott, Rosedale, Miss.

Great Lakes.—James H. Davidson, Oshkosh, Wis.; E. W. Wickey, South Chicago, Ind.; H. C. Bartow, Chicago; Edward H. Butler, Buffalo.

Ohio Valley.—W. B. Rodgers, Pittsburg; Albert Bettinger, Cincinnati; John L. Vance, Columbus, Ohio; W. H. Keller, Evansville, Ind.

Tennessee and the Cumberland.—M. T. Bryan, Nashville, Tenn.

Arkansas Valley.—John A. Fox, Arkansas.

Missouri Valley.—Lawrence M. Jones, Kansas City; George C. Call, Sioux City, Iowa.

Pacific Coast.—N. G. Bialock, Walla Walla, Wash.; A. H. Devers, Portland, Ore.; George C. Pardee, Oakland, Cal.

EXPRESS CARRIED BY ELECTRIC RAILWAY gives the Wells-Fargo Express Co. an entry into Pittsburg. On Dec. 1, under a new arrangement, the company began to carry its express matter from Butler, Pa., to Pittsburg, 40 miles, by electric cars over the Pittsburg & Butler Street Ry. The service of the Wells-Fargo Company in the East is operated over the Erie R. R. The Pittsburg connection is made from Shenango, on the Erie, to Butler via the Bessemer & Lake Erie. The street railway service completes the connection as described.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.

The third annual meeting of the American Society of Refrigerating Engineers was held in the Engineering Societies' Building, in New York City, on Dec. 2 and 3. For the past two years these meetings have been held in New York just preceding the annual meeting of the American Society of Mechanical Engineers, to which many of the members of the smaller society belong. The refrigerating engineers, though covering but a limited field, have developed a thorough and enthusiastic organization, and in attendance at their meetings and interest displayed in their proceedings are worthy of emulation by some of the larger associations. Out of a total membership of somewhat over 150, more than 100 members were in attendance. Four business sessions were held, on the morning, afternoon and evening of the first day and on the morning of the second day, in addition to a banquet on the evening of the second day.

The president of the society, Prof. D. S. Jacobus (New York), was unable to attend on account of pressing duties on the Pacific coast, but forwarded a presidential address of a non-technical nature. In his absence, Mr. John E. Starr (New York), a past-president of the society, acted as chairman.

In the course of the meeting it was announced that the York Manufacturing Co., of York, Pa., had presented to Sibley College, of Cornell University, a large refrigerating plant for test purposes, and that this plant was open to the members of the society for any suggestions as to tests to be made during the coming year. This, in a way, supplants the testing plant of the same company at their home office at York, which was intended, two years ago, to be used for any testing work that the society might suggest.

PAPERS AND ADDRESSES.

COLD STORAGE BY MEANS OF ICE.—Under the above title, Mr. Madison Cooper (Watertown, N. Y.) defended the use of ice in cold-storage houses. He described the various systems using ice to induce low temperatures, beginning with the original invention of Prof. Nyce, in which an insulated house was constructed with storage on the first floor and ice above, absolutely separated from the lower chamber by a water-tight galvanized iron floor. The cooling was accomplished by direct transmission through this floor to the air of the storage room. Various other later, but less desirable, systems were designed as an attempt to improve on Prof. Nyce's scheme, but as a rule the effort to get the ice nearer to the stored material resulted in a too great moisture in the storage room. In the best of these, the Dexter system, an improvement was made in that the cold air was led by means of flues into the storage room, and, when its temperature had raised, back into the ice room again to be cooled.

As an advance on these systems came what is known as the Direct Tankage System, in which large tubes or hollow walls are used to transmit air cooled by passing over a salt and ice mixture. This is open to many disadvantages, more particularly the large amount of room taken up by pipes, the moisture which is formed by the pipes which allows dripping on the stored goods, and finally the inability to maintain an even temperature, owing to the variable thickness of frost which forms on the pipes. As an improvement on all these schemes, Mr. Cooper has designed his own system, which he briefly described as follows:

Essentially, the Gravity Brine System consists of a continuous pipe, a portion of which, in the form of a coil, extends through a tank or receptacle which is filled with a mixture of broken ice and salt; and another portion of which, exposed at a lower level, extends through the room or medium to be cooled. The pipe is first filled with brine of the proper density; the coil in the tank is surrounded with ice and salt; and the system is immediately in operation. The brine being cooled in the tank becomes heavier and circulates down into the portion of the pipe at a lower level and surrounded by a comparatively warm medium. Becoming warmer and lighter, it circulates upwards into the portion of the pipe in the tank. Ice and salt be[illegible] maintained in the tank, it will be readily seen [illegible] the circulation will be continuous. The system op[illegible]s on the same principle as a hot water heating pla[illegible]t in a reverse direction. It might be stated in pa[illegible] that the patent claims allowed on this system c[illegible] not only the gravity circulation as described, but a [illegible]culation of brine under this arrangement by mea[illegible] of a pump. Temperatures as low as 10° F. are ob[illegible]nable with the Gravity Brine System in practical o[illegible]tion, and a temperature of 6° F. has been produced o[illegible] test.

This system is claimed to be desirable [illegible] account of its economy of operation, its [illegible]fety against stoppage or breakdown, its eas[illegible] and simplicity of operation, the uniformity of [illegible]emperature produced, and the perfection [illegible] the results. With it is used extensively a p[illegible]ess by which chloride of calcium is so plac[illegible] as to absorb the moisture from the pipes. [illegible]s to costs, it was noted that a meat market in Minnesota, with 40,000 cu. ft. of cold-storage space, consumed 553 tons of ice, costing $1.65 [illegible] ton delivered, and 67 tons of salt, costing $7 per ton, to procure a temperature of 15° F. through the year 1904.

In the discussion it was stated that the Gravity Brine System was very effective where ice was cheap and only a moderately low temperature was desired; for low temperature, or where ice costs were high, a mechanical plant seemed more economical.

THE AUTOMATIC REFRIGERATING MACHINE.—Mr. Van R. H. Green (New York) described a machine on the market for use in small refrigerating plants, such as are found in restaurants and hotels, either as an ice-making machine or as a cold-storage plant. The machine is regulated automatically by a thermostat located in the low temperature rooms, so that it runs only when the temperature is in need of being lowered, automatically stopping when the thermometer registers within a predetermined 4° F. limit. Considerable opposition to this machine was shown in the discussion, many of the members claiming that in no way other than by constant attention by experienced engineers could a plant be economically run to produce a consistent temperature.

FIREPROOF COLD-STORAGE WAREHOUSE CONSTRUCTION.—Mr. John E. Starr described, in some detail, three types of fireproof cold-storage construction which had come under his immediate supervision. These types were:

Class A. Cold storage buildings erected with outer and inner walls of tile, the outer wall not carrying any weight but its own, and the floors a combination of concrete and tile, weights carried on the inner walls and partitions. Insulation between inside and outside wall a continuous fill.

Class B. Cold storage warehouse containing an inside building, with reinforced-concrete columns and girders, and with floors of either reinforced concrete or combination of reinforced concrete and tile, all weights carried on columns. Outside walls either of brick or tile, or a combination of both. Inside walls of vitrified tile, Insulation between inside and outside walls a continuous fill.

Class C. Cold storage building with iron framework with weights carried partially on columns and partially on outside brick walls, all ironwork covered with fireproofing. Inside wall of vitrified tile. Insulation between inside and outside walls a continuous fill.

Under Class A he described a three-story house at Washington Court House, O., in which the 8-in. space between the two outer tile walls, and between partitions, were filled with a granulated cork filling. Under Class B the most notable example was a nine-story storehouse at St. Paul, Minn., constructed entirely of reinforced concrete, with a double facing wall filled in between with cork. Additional insulation was also provided by coating the tops of all floors with cork boards, two to four inches thick. It is a remarkable fact that though the inside of this house is frequently at as low a temperature as five below zero, F., with the outside wall above 100° F., no signs of cracking, due to expansion, have ever been noticed.

WET COMPRESSION SYSTEM OF REFRIGERATION.—Mr. Carl W. Vollman (Montreal, Can.), in a paper entitled, "Advantage of the Wet Compression System," strongly advocated this method of refrigeration, in which ammonia

is allowed to evaporate only to such a point that small particles of wet ammonia are carried back to the compressor, there to absorb during compression a part of the heat developed, thus keeping the compressor at normal temperature. The reasons which he gave for the superiority of this system were severely criticised by many members on the ground that they were mere statements of opinion, unsupported by experiment, and that, in fact, all tests tended to show the fallacy of the statements produced. Mr. Vollman was not present at the meeting, so the paper was passed without further discussion.

Mr. Thomas Shipley (York, Pa.), in a paper entitled, "The Comparison of Bids for Ice-making and Refrigerating Machinery," entered a plea for a more analytical consideration of the details of design and operation in estimating the value of plants, either for construction or purchase. He condemned certain fixed methods of estimating the efficiency of the various portions of the machinery, which methods depend more on rules-of-thumb than upon an ordered knowledge of the performances of the mechanism. Several tables were presented comparing different types of refrigerating machinery, which were tested at the testing plant of the York Manufacturing Co.

PLATE ICE MANUFACTURE.—Mr. Irving Warner (Wilmington, Del.) related, in a paper, some of the details of management and operation in a plate ice plant. He first showed his system of measuring the daily growth of the ice in the tanks, by means of which a tabulated record could be made of all the different sections of the plant and the actual working conditions closely watched. Detailed figures of steam consumption in the various operations of the plant under a long-time test were also presented in tabulated form. Methods of plotting adiabatic curves on diagrams, the effectiveness of thermometric testing of compressors and the difficulties in removing the ice from the tanks made up the remainder of Mr. Warner's paper.

CONCRETE ICE TANKS.—The statement in one of the papers that, on account of the remarkably good condition of a 17-year-old wooden ice-making tank, tanks of wood should be of much greater service than those of concrete, brought forth a long statement from Mr. Abram Day (Newark, N. J.) in defense of the concrete ice-making tank. Mr. Day started in some seven years ago, to investigate concrete for this use. He built a concrete tank, 2.5 × 3 × 3 ft. in size, and placed within it refrigerating coils and froze the enclosed water snug up against the walls of the tank, with no apparent injury to the material. Repeated tests of this sort persuaded him to build in a Newark plant seven working tanks, each about 20 × 12 × 20 ft. in size. These have been in use some years and show no signs of deterioration. Owing to certain other tests, in which repeated freezing and thawing of water in concrete tanks caused marked weakening of the concrete, Mr. Day makes it a rule to take out the ice before it has reached the sides of the concrete tanks. In practice he uses usually a 1:2½:5 concrete, reinforced with ½-in. rounds, and finished off with neat cement and not waterproofed. Several of these tanks have been built, and in every case a satisfactory result has been attained.

TRANSPORTATION OF PERISHABLE FRUITS.—Mr. S. T. Dennis, of the United States Department of Agriculture, outlined to the society certain investigations about to be published by the Department describing a series of tests made upon the transportation of oranges from California to New York. The fruit was loaded at California under the following conditions: (a) just as it came from the warehouse, (b) carefully brushed and selected, and (c) precooled. They were sent across the continent in refrigerator cars, observations of temperature being taken en route, and the condition of the fruit being noted on its arrival. It was found that the precooled fruit was far in advance of any other in its degree of preservation. For this reason it is expected that the fruit interests of the Pacific coast will in the near future construct plants for the cooling of the fruit before it is placed in the refrigerating cars. The exact nature of these plants, whether they will be units at each fruit warehouse, or a large central system at the loading place, is largely a matter of future consideration.

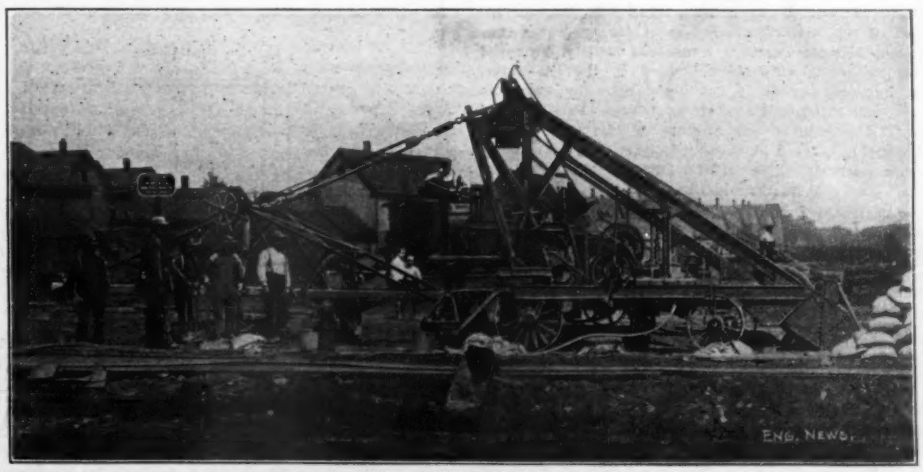
Mr. T. G. Sparks (New York) detailed some laboratory methods for the determination of impurities in ammonia in refrigerating plants. Mr. R. L. Shipman (Cornell University) presented several tables showing the results of tests on "Heat Transfer in Coolers and Condensers of the Double-Pipe Type," which tables will not be wholly available until the publication of the transactions of the society. Mr. R. B. Dale (United States Geological Survey) outlined for the benefit of those members of the society who are not familiar with the work of the water resources branch of the Survey the various data that this branch of the government is collecting which might be of interest to any one about to use for refrigerating purposes the water from any of our large rivers.

OFFICERS.

The following officers were elected for the ensuing year: President, Mr. Edgar L. Penney (Newburgh, N. Y.); First Vice-President, Mr. James Wills (New York); Second Vice-President, Mr. Karl E. Vesterdahl (New York); Treasurer, Mr. Walter C. Reid (New York). Mr. Wm. H. Ross, 154 Nassau street, New York, is Secretary, and to him should be addressed all communications relative to the publications of the society.

CONCRETE MIXING AND SPREADING MACHINE FOR STREET WORK.

Machines for distributing concrete have been employed in several cases in street construction work, to avoid the amount of manual labor otherwise required to distribute the material by means of wheelbarrows. The accompanying cut represents a self-propelling mixing and spreading machine which has been used on work of this kind at Buffalo, N. Y. The frame or bed carries a 11-ft. cubical concrete mixer, a 16-HP. gasoline engine of the automobile type, and a frame upon which rides a hopper for delivering the material of each batch into the mixer. Beyond the frame projects a 25-ft. boom carrying a track upon which rides a dumping bucket. The head of the boom is supported by guys, while at the middle is a cross frame having small wheels which rest on the graded surface of the street. The boom is pivoted at its inner end, and has a horizontal swing of 170°, so as to cover the width of a 50-ft. street. The machine



SELF-PROPELLING CONCRETE MIXING AND SPREADING MACHINE FOR STREET WORK.
(Municipal Engineering & Contracting Co., Chicago; Builders.)

weighs 15,000 lbs. in working order. A modified form is to be built with a steam engine and marine boiler. This machine was designed and built by the Municipal Engineering & Contracting Co., of Chicago, and we are indebted to that company for information.

In operation, the materials are distributed along the street, and the proper proportions for a batch are loaded into the hopper, which is shown resting on the ground in its loading position. The hopper is then hauled up the inclined track, and dumps its contents into the mixer. Water is supplied from an elevated tank, the quantity being automatically measured. The finished concrete is discharged from the other end of the mixer into the wheeled bucket, which is then run out on the boom to any desired point and there dumped. In the work at Buffalo, the ordinary gang consisted of 17 men, including the foreman, and this force laid from 110 to 120 cu. yds. per hour. The highest record was 1,000 cu. yds. in an eight-hour day.

A CEMENT WHICH IS PROOF AGAINST SEA-WATER.

It is commonly understood that the factors of safety used in designing timber and concrete construction must be higher than those used in steel work, on account of the uncertain nature of the two former materials. Wood is a natural product, subject to all the variations of an organic compound, and therefore its structure must be accepted as it is found and the high factor of safety applied to take care of its unknown weaknesses. Cement, on the other hand, though a manufactured product like steel, does not show the close adherence to standard physical properties as does the metallic compound. Although the larger part of the reliability of concrete work depends on the sand, stone and methods of mixing, there is still a feeling among many engineers that the cement should be made not only with more uniform properties but of a higher strength. In a recent paper read before the Western Society of Engineers, Mr. Wm. Michaelis, Jr., of Chicago, presented some reasons why we have probably reached the limit of perfection in the ordinary clay-limestone Portland cement. He also called attention to a new iron-limestone cement, now being made in Germany, which promises to be an improvement in some respects over the standard Portland product.

A portion of Dr. Michaelis' paper follows:

Cement will not be improved in the future; we have arrived at the limit of its good qualities. This statement refers to Portland cement, of which every builder in this country thinks whenever the general term "cement" is used. Why can Portland cement not be improved? In order to be able to answer this question, it must be remembered that Portland cement is a product obtained by calcination of an intimate mixture of finely pulverized limestone and clay or shale, and that it consists of calcium silicates and calcium aluminates. Clay and limestone may be mixed in all possible proportions, but the result from a chemical standpoint will never be anything better than our present commercial Portland cement. Then, if the chemical composition of Portland cement cannot be improved, cannot ith physical properties be altered, can it not be ground more finely? Yes, this latter can be done, indeed, but it would not be of any practical value.

Recent investigations have proven that in commercial Portland cement only from 30% to 40% possess cementing properties at all; the remaining 60% to 70% represent inert material. Until a short time ago, you could read in cement literature that the cement remaining on a 200-mesh sieve is too coarse, that is to say, has no hydraulic properties, and that everything that passes

the 200-mesh sieve represents the active part of the commercial cement. Today the 200-mesh sieve exists only for the manufacturer in order to enable him to grind his clinker always to a certain fineness required by the specifications. The experimenter, however, can no longer make use of so coarse a screen as a 200-mesh sieve. He divides the cement into that part which remains on an 800-mesh sieve, which is inert (about 60—70%), and that which passes the 800-mesh sieve (30—40%), which is cement proper. Of course, an 800-mesh sieve does not exist. It would have meshes 1/1600 in. wide and would consist of wire gauze of the same thickness. In order to obtain this fineness, the imaginary sieve is replaced by a process of decantation or elutriation in a current of alcohol of a certain velocity which separates the fine from the coarse and leaves the grains that measure more than 1/1600 in. under the microscope.

If the manufacturer would grind his Portland cement to this extreme fineness or even only to a fineness between the 800-mesh sieve and that of the commercial cement of today, say to 70% passing an 800-mesh sieve, the resulting product would be so quick-setting a cement that nobody would be able to use it in practice. A neat or a sand mortar briquette may be made of it possessing a strength several times higher than the strength obtained from Portland cement of the present fineness, but this is only under the assumption that the mortar be gaged with the water less than a minute. If the gaging should continue for several minutes, no higher strength than for ordinary cement can be obtained. This is due to the quick-setting qualities of the calcium aluminates in the Portland cement. No addition, however great, of any retarding element, can prevent this. So finely ground a Portland cement, therefore, could not be used in actual practice, where under the best conditions a quarter of an hour is required from the time of mixing the concrete until it is tamped into the forms or molds. I have frequently made such experiments with cement of extreme fineness separated from the coarser particles by an air-current for instance, with cement that had been collected on the top of a 30-ft. ventilating tube over grinding machinery, and from these experiments I know that such Portland cement will never fulfill the demands of engineers and architects who are eagerly looking for a cement of higher crushing strength than our present Portland cement. Architects rightly wish both for economic and mechanical reasons, to disuse reinforcement in concrete columns. As long as they make use of Portland cement for their concrete, they will have to design columns of enormous proportions, if they want to omit reinforcing bars or spiral reinforcement. Therefore the desire for a much better grade of cement, which according to a recent utterance of a well-known engineer, "would receive an enthusiastic reception by all engineers." Fortunately such a cement exists.

IRON-ORE CEMENT.—The cement to which I refer is "Iron-ore Cement" which has been manufactured for several years in Germany, and which I hope will soon be manufactured in the United States also. This cement is made of limestone and iron-ore instead of using limestone and clay as in the manufacture of Portland cement. It was originally manufactured with the sole intention of replacing Portland cement for sea-water construction, because Portland cement is rapidly destroyed by the magnesia sulphate contained in the sea-water, while iron-ore cement is not acted upon by even the most concentrated solution of sulphates. This iron-ore cement, if ground to the fineness of commercial Portland cement, is very slow setting, because of its chemical composition, which differs from that of Portland cement inasmuch as the aluminates of the Portland cement are replaced by iron compounds, by calcium ferrites. The aluminates of the Portland cement, as mentioned above, are the cause of its quicksetting properties. The calcium ferrites of the iron-ore cement, however, hydrate only slowly, so that this cement has only a comparatively low strength after a day or a week. But its strength steadily increases from month to month and year to year, soon reaches that of Portland cement and in time far exceeds its maximum strength, so that a barrel of iron-ore cement goes much farther than a barrel of Portland cement even under ordinary conditions, that is to say, if both are ground to the same present day's fineness. Now let us grind iron-ore cement to extreme fineness, which can easily be done by air-separation; then it will finally become as quicksetting as commercial Portland cement is now, it will contain perhaps 70-80% of active material in opposition to the 30-40% of Portland cement of the same setting properties and a barrel of such finely pulverized iron-ore cement will replace three barrels of Portland cement and will enable the architect either to use leaner mortars or to considerably reduce the dimensions of columns and beams, while, as mentioned before, the same cannot be done with Portland cement. Moreover, a better grade of cement could be shipped farther, as the consumer would obtain in the contents of one barrel of cement the same amount of cementing material that he gets out of three barrels now.

Some further properties of this cement were described in the "Cement Age" for January, 1907, by Mr. S. B. Newberry. A portion of this article is given below:

It was proved by Dr. Michaelis, of Berlin [Father of the Dr. Michaelis mentioned above.—Ed.], many years ago, that a cement consisting of silica, lime and iron oxide, and containing no alumina, has all the qualities of the best commercial Portland. Patents on this new cement have been obtained in Europe and the United States by Dr. Michaelis, and assigned to the Krupp Steel Co. Its manufacture, under the name of "ore-cement" (*Erz cement*) has been begun on a considerable scale at Hemmoor, Germany. The materials used are silicious limestone and iron ore, or pure limestone and silicious iron ore. These are ground together in suitable proportions and burned and ground in the ordinary manner. The product is a dark-colored cement, of higher specific gravity (3.31) than ordinary Portland, and slightly slower setting. It is constant in volume, and shows very high strength in tension and compression. Mixed with plaster in any proportion it remains perfectly sound, and when exposed to the action of the sea-water of five times normal strength under pressure of 15 atmospheres—conditions which destroy ordinary Portland within a few days—it shows no trace of expansion or cracking.

The composition of the ore cement, as compared with an average commercial Portland, is as follows:

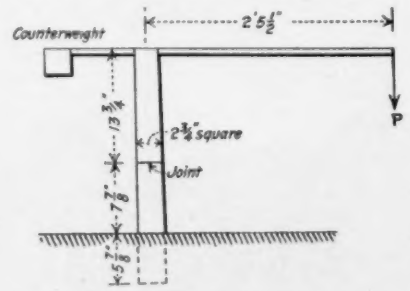
	Portland Cement	Ore-Portland Cement
Silica	22.0	20.5
Alumina	8.0	1.5
Iron oxide	2.5	11.0
Lime	63.5	63.5
Magnesia	1.5	1.5
Sulph. Anhyd.	1.5	1.0
Alkalies, loss, etc.	1.0	1.0
	100.0	100.0

It will be noted that the ore cement contains a small amount of alumina; this is almost wholly derived from the ash of the fuel used in burning. It is, however, not necessary that the percentage of alumina should be kept as low, even, as 1.5. No injurious action of concentrated sea-water was found at the Charlottenburg Royal Testing Station in a long series of careful tests of two ore cements containing respectively 3.39 and 3.47% alumina.

EFFICIENCY OF CEMENT JOINTS IN JOINING OLD CONCRETE TO NEW.

Experiments showing the value of a cement wash in joining new concrete to old have just been reported by M. Mesnager in Annales des Ponts et Chaussees, the 3d part of v. 27, 1907.

A number of concrete prisms were made, under the ordinary conditions which exist in actual work, by workmen who were familiar with concrete. After these prisms had set, in one series for 7 days in the other for 30 days, a prism similar in section and length was joined to each of the first, using a cement wash at the



joint in a portion of the tests and merely wetting the connecting plane in the remainder. The joined pieces were then tested by flexure, as noted below.

The test pieces were made of a 1:2:4 concrete in prisms 2¾ ins. square in section and 13¾ ins. long. The first block was cast in a horizontal position and the material well rammed into place. After it had set under damp cloths for 7 or 30 days the second block was added on one of the 2¾-in. square ends cut in a vertical position, and well rammed down into place. The face upon which the second prism was placed was plane, just as it came from the forms, with no additional scoring or marking. Two series of tests were made simultaneously; in the first the joint was well wetted before adding the second block; in the second the connecting plane was washed with a pure cement grout, called in France "barbotine." The jointed pieces were then laid away under wet cloths and tested 28 days after the last block had been cast.

The flexural tests were made by the device shown diagrammatically in the accompanying figure. The block was set vertically and firmly held for a distance of 5⅞ ins. in a solid base. At the top there was then attached a grooved horizontal bar, tightened to the block by a set screw not shown in the diagram, and carrying at one end a pail into which mercury was poured. At the other end of the bar there was a counterweight so adjusted that the center of gravity of the whole horizontal system, exclusive of the mercury in the pail, would come directly over the center of the test piece. In making the test the mercury was poured in the pail until the test piece broke.

The stresses to which the pieces were subjected were computed as follows:

Let P = weight of mercury.
P_1 = weight of horizontal system.
l = lever arm of P around block.
b = side of block section.

Then there exists on any horizontal plane in the block a uniform pressure equal to the weight of the mercury plus the horizontal system and also an eccentric stress due to the moment of the mercury around the block. The outer fiber of the block is therefore subjected to the following stress:

$$S = \frac{P + P_1}{b^2} \pm \frac{M\,b}{2\,I}$$

Taking the tension side of the section and substituting for I its value $\frac{b^4}{12}$ and for M its value $P\,l$, the tension in the outer fiber becomes

$$T = \frac{6\,P\,l}{b^3} - \frac{P + P_1}{b^2}$$

from which formula the stresses in the following tables are computed, with a value of 42.9 lbs. for P_1.

It will be noted that the blocks, in nearly every instance, broke at some distance above the joint, in which case the loading device was attached to the new upper portion of the test

TABLE SHOWING EFFECT OF CEMENT JOINTS IN CONCRETE WORK.

Test No.	Tests on each piece.	P Breaking load, lbs.	T Tension in outer fiber, lbs./sq.in.	Remarks.
		I.—Second piece placed 7 days after first.		
		(a) Without cement joint.		
1.	I.	3.5	24	Broke ⅞-in. above joint. } Faulty
	II.	3.5	24	Broke at joint. } joint.
2.	I.	12.2	97	Broke at joint.
3.	I.	8.7	67	Broke at joint.
Average.....			82	Disregard Test No. 1.
		(b) With cement joint.		
4.	I.	23.4	191	Broke 8 ins. above joint.
	II.	24.3	198	Broke 4 ins. above joint.
	III.	25.6	209	Broke at joint.
5.	I.	21.9	178	Broke 1¼ ins. above joint.
	II.	21.6	175	Broke at joint.
6.	I.	24.8	202	Broke 1¾ ins. above joint.
	II.	24.6	200	Broke at joint.
Average.....			193	
		II.—Second piece placed 30 days after first.		
		(a) Without cement joint.		
7.	I.	24.5	199	Broke 7½ ins. above joint.
	II.	24.9	202	Broke 4 ins. above joint.
	III.	21.2	171	Broke at joint.
8.	I.	13.9	111	Broke 10½ ins. above joint.
	II.	19.1	154	Broke at joint.
9.	I.	17.7	142	Broke at joint.
Average.....			163	
		(b) With cement joint.		
10.	I.	21.5	174	Broke 11¼ ins. above joint.
	II.	24.6	200	Broke 9¼ ins. above joint.
	III.	29.0	234	Broke 2½ ins. above joint.
	IV.	19.7	159	Broke at joint.
11.	I.	5.5	91	Broke 8¾ ins. above joint.
	II.	26.5	216	Broke 4½ ins. above joint.
	III.	31.6	259	Broke 2 ins. above joint.
	IV.	36.7	302	Broke at joint.
12.	I.	24.3	198	Broke 10 ins. above joint.
	II.	27.8	227	Broke 5½ ins. above joint.
	III.	26.6	217	Broke 2½ ins. above joint.
	IV.	27.8	227	Broke at joint.
Average.....			219	Disregard Test 11, No. I.

Note.—In the 30-day tests the second piece was tamped onto the first piece with much greater force than in the 7-day tests.

piece and the loading continued until the break finally occurred at the joint.

The apparent decrease in efficiency in the use of a cement joint when the old work is 30 days old over that when the first piece is only 7 days old is probably due to the more energetic ramming of the new material in the former case. The breaks in the 30-day specimens presented a much more compact texture than those in the 7-day pieces.

The general conclusions are that a cement joint is an aid in connecting old concrete work to new and that whether this joint is used or not, an excessive tamping of the new work near the joint will add appreciably to the strength of the connection.

DUMP CARS OF LARGE CAPACITY FOR CONSTRUCTION WORK.

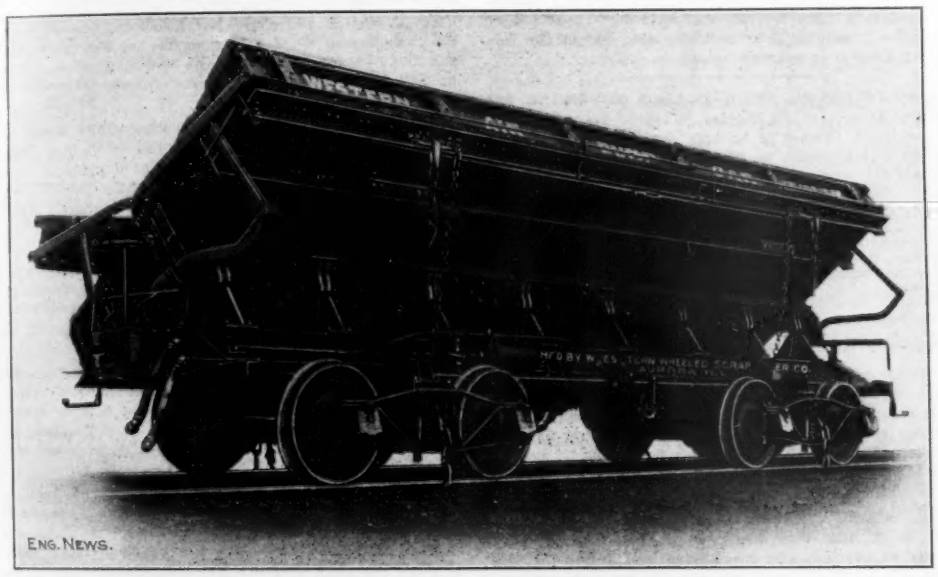
While side-dump cars have been employed very extensively in contract and general construction work for a number of years, they have mainly been of small size for use on temporary or construction tracks (usually of narrow gage), and in connection with small locomotives. There are many cases where it would be an advantage to handle excavated material in dump cars hauled in regular work trains on the main tracks, especially where there is a long haul; but there has been general objection to permitting dump cars to be operated in this way, on the ground that such cars, being often of comparatively light and rough construction, would be liable to break down and cause delay and interference to regular traffic. Within the past few years, however, there have been developed dump cars of large size, adapted for service on main tracks and capable of effecting material economy in the cost of the work.

The dumping of large cars by hand would involve serious delays, and apparatus has therefore been devised for accomplishing this by means of compressed air from the locomotive. The accompanying cut represents a large-size air-operated dump car designed for use on main line railway construction and similar work. It is built by the Western Wheeled Scraper Co., of Aurora, Ill. The cars are built in sizes of 12, 15 and 18 cu. yds. capacity; and the light weights for these sizes are about 29,000 lbs., 36,000 lbs. and 42,000 lbs. respectively. Large numbers of these cars are now in use, and their introduction has led to some important changes in methods of construction with material reductions in cost. The car underframe is of steel, and its principal members are the center sills, which also serve as the draft beams. These are built up of two steel I-beams to which are attached the air-dumping device, air brakes and piping. The car bed when dumping strikes spring buffers which are riveted to the body bolsters. The floor or bed of the car is supported on a central girder to which are attached the trunnions on which the bed rocks. The door on each side is stiffened by two angles and two truss rods, the latter being furnished with turnbuckles for keeping them tight. The upper edge of the door is protected by a third angle. The lumber is all of 3-in. long-leaf yellow pine. M. C. B. trucks are used, with 33-in. wheels, malleable-iron journal boxes, I-beam bolsters, and spring-planks of steel channels. The cars are equipped with automatic couplers and air brakes, and are sufficiently strong and well equipped for handling on main lines without any fear of causing delay to regular traffic.

The bed of the car is pivoted over the center sills and will dump on either side. The side doors are operated automatically by toggle arms at each end of the body. When the body of the car is tipped, the toggle strikes a plate on the truck and holds the door from dropping with the bed. The arms are pivoted both to the door and to the bed in such a manner that as the bed is tilted the door does not merely remain stationary, but is thrust outward and upward away from the load. This reduces the resistance to dumping, saves the door from injury and gives a wide opening for the discharge of the material, allowing large boulders or frozen chunks to fall without clogging. The bed tips to an angle of 47°.

The bed is dumped and returned to its normal carrying position by compressed air, and the operations are controlled by the engineman by means of a special valve in the cab. The mechanism on the car consists of a cylinder and a set of levers, chains, shafts and cams for each side of the car. The thrust of the piston-rod acts on the lever which transmits the motion to a shaft through a chain operating over a cam. On the same shaft are two other cams to which the dumping chains are attached, the upper ends of the dumping chains being fastened to the outer sills of the bed. The action of the lever causes the shaft to rotate, drawing the bed down to the dumping angle. The return of the bed to level position is accomplished by similar action of the mechanism on the opposite side of the car. The air used in dumping the car is passed to the opposite cylinder and serves to return the bed to its normal position. Straight air is used, no auxiliary reservoir being required.

Only one man is needed on the dump, whose duty is to fasten and unfasten the safety chains which secure the body in level position.



AIR-OPERATED DUMP CAR OF 12 TO 18 CU. YDS. CAPACITY.
Western Wheeled Scraper Co., Aurora, Ill., Builders.

THE LIFE AND PRESERVATION OF PITCH-PINE FENCE POSTS.

Experiments on the preservation of pitch-pine fence posts, extending through 16 years, conducted by Mr. B. C. Buffum, are described in Bulletin No. 75 of the Wyoming Experiment Station, Laramie, Wyo. Pitch-pine posts of average character, from posts bought to fence a 40-acre lot at the Experiment Station, were selected for test. The posts were set between two irrigation laterals, within 4 or 5 ft. of one and within 12 or 13 ft. of the other. The 80 posts chosen for test were divided into sets of 5 and, after treatment, were set to a depth of 2 ft., one rod apart. The treatment given the several sets is described as follows:

No. 1. Well coated with tar to a distance of 2½ ft. from the bottom of the post.
No. 2. Good, clean posts, not treated, as a check.
No. 3. Treated with crude oil, or petroleum, 2½ ft. of the bottom of the post.
No. 4. A tar band 1 ft. wide, 18 to 30 ins. from the base, to protect the wood near ground surface.
No. 5. Crude oil band 1 ft. wide, from 18 to 30 ins. from the base.
No. 6. Crude oil covering 2½ ft. of the bottom of the post, and the oil burned off.
No. 7. Coating of tar 2½ ft. of the bottom, and the tar burned off.
No. 8. Band of crude oil 1 ft. wide, from 18 to 30 ins. from the base, and burned off.
No. 9. Good posts, untreated, as a check.
No. 10. Tar band 1 ft. wide, 18 to 30 ins. from base, and burned off.
No. 11. 1 ft. of bottom dipped in tar.
No. 12. 1 ft. of bottom dipped in tar and tar burned off.
No. 13. Poorer posts, containing little pitch, untreated.
No. 14. Good, well charred posts; 2½ ft. of the bottom of these posts was simply burned to produce a protecting char.
No. 15. 1 ft. of bottom dipped in crude oil.
No. 16. 1 ft. of bottom dipped in crude oil, and oil burned off.

The posts were treated and set on April 15, 1891, and were left undisturbed until June 27, 1907, or a little over 16 years. On the latter date they were removed. The results of examination subsequently made are expressed in tabular form, as follows:

A general explanation of the method of percentage rating is given in the bulletin as follows:

If the post was in perfect condition the mark will be 100%; if entirely rotted off, so it would stand no longer in the fence, the percentage will be 0; if the estimation showed 50% gone with dry rot, the condition would be 50%, and so on. These figures give a comparative idea of the effects of different methods of treatment and of the life of the posts not treated. In the notes following each set of data in the tables an attempt is made to estimate the life of each post. In the cases where they have probably been rotted off for one or more years, the notes indicate that the life of the post was that much less than the length of time since the experiment was begun. On the other hand, if in the opinion of the observer the post would last a longer time, the total life of the post is indicated. For example, in the fourth set of posts it is estimated that one would last four years longer, and the notes state "one 20 years," indicating that the total life of the post would be 20 years. Two of these posts had been rotted off for four or five years, and the notes state that their life was about 12 years.

In addition to the condensed information given in the table here reproduced, the bulletin contains

EXPERIMENTS WITH PITCH-PINE FENCE POSTS.

Set No.	Treatment.	Number. Whole.	Number. Broken.	Condition, per cent. Ground surface. Bottom.	Condition, per cent. Ground surface. Ground surface.	Condition, per cent. Ground surface. Top.	Notes.
1	Coal tar 2½ ft. bot.	4	1	100	65	85	One gone at 15 yrs.; 4 would last 20 or 25 yrs.
2	No treatment.....	2	3	30	12	85	Three gone at about 12 yrs.; 1 would last 17 yrs.; 1, 18 yrs.
3	Crude oil 2½ ft. base	5	0	95	75	90	Two would last 20 yrs.; 3 perhaps 30 yrs.
4	Tar band 1 ft. wide	3	2	75	50	95	Two good as new; 1, 20 yrs.; 2, about 12 yrs.
5	Crude oil band....	5	0	95	90	98	Four good as new; 1 good for 25 yrs.
6	Crude oil, burned.	5	0	100	98	85	All 5 practically good as new; should last 30 yrs. or more.
7	Tar 2½ ft., burned	5	0	60	50	95	One good as new; 4 would probably last 20 yrs. or more.
8	Crude oil band and burned	2	3	60	15	90	One good for 18 yrs.; 3 have been broken 3 or 4 yrs.; 1 gone this year.
9	No treatment.....	4	1	40	35	90	One good for 20 or 25 yrs.; 2 gone now; 1, 17 yrs.; 1 off several yrs.
10	Tar band, burned.	3	2	5	40	85	Two good for more than 20 yrs.; 2, 14 yrs.; 1, 16 yrs.
11	Tar 12 ins. base...	5	0	75	50	95	All would probably stand to 25 yrs.
12	Tar 12 ins., burned	4	1	50	40	80	Two would last 20 yrs.; 2, 18 yrs.; 1 broken a yr. or more.
13	No treatment.....	2	3	00	7	80	One might stand 17 yrs.; 2, 16 yrs.; 2, 14 yrs.
14	Well charred.....	4	1	70	65	90	Two, 25 yrs.; 1 broken would have stood 17 yrs.; 2, 20 yrs. or more.
15	Crude oil 12 ins. base	2	3	...	40	90	Two good for 20 yrs.; 1, 16 yrs.; 1, 15 yrs.; 1, 14 yrs.
16	Crude oil 12 ins. and burned.....	2	3	...	30	90	Two may last to 20 yrs.; 2 gone this year; 1 gone 2 yrs. ago.

detailed notes. The final summary of results as given in the bulletin is as follows:

The best treatment, and one which was eminently successful in preserving the posts, was dipping the lower ends in crude petroleum and burning off the oil a sufficient distance to come above the ground when set. This seems to drive hot oil into the post, which with the protecting char cover keeps it from decay. The 16 years had made but slight inroads on the posts thus treated, and they apparently would last indefinitely. This dipping can be done very cheaply, and will undoubtedly pay.

Simply dipping 2 ft. of the bottom of the posts in crude oil or in tar did fairly well. The oil seemed a better protection to the posts than did the coal tar. Posts that were well charred by burning came in about third place.

Under our conditions good pitch-pine posts, without treatment, will last from 12 to 25 years after being set in the ground.

There is little advantage to be gained by simply oiling or tarring a band to protect the post from dry rot where it comes through the ground, and less from any treatment of only a portion below the ground. Such oil band helped preserve the post, but the time taken to apply the oil in this manner would make it more expensive than dipping the entire lower end of the post.

A BOILER EXPLOSION on Dec. 8 on the Chunchumil hacienda near Merida, Mexico, killed five persons and seriously injured ten others.

A RUNAWAY TROLLEY CAR, going down the steep Perrysville Ave. grade in Allegheny, Pa., on Dec. 7, jumped the track at a curve at the bottom and completely overturned, seriously injuring about 16 persons, three of whom are not expected to live.

THE WORST RAILWAY WRECK OF THE WEEK, in which five were killed and about 40 others more or less injured, occurred on Dec. 4 on the Washington Branch of the B. & O. R. R., about 11 miles south of Baltimore. The accident bears a remarkable similarity to the wreck at Terra Cotta on another branch of the same road in which more than 50 persons were killed about a year ago (Eng. News, Jan. 10, 1907). An express train, traveling at full speed early on a foggy morning, crashed into the rear of an accommodation which was some 25 minutes late and was taking on passengers at Hanover station, and completely telescoped the two rear cars. No one on the rear train was hurt. There has recently been installed on this division an electric system of automatic block signaling, but the engineer of the express states that the signal, at the beginning of the block in which the accommodation was, showed white for a clear track. The signal officials of the company, however, claim that the automatic system worked properly, but the engineer disregarded the red danger signal displayed.

Other serious railway accidents of the week include a rear collision, Dec. 2, on the B. & O. R. R., at Shenandoah Junction, W. Va., in which two colliding freight trains side-wiped three cars on a St. Louis-New York express. Three passengers were killed and 12 injured.

THE WORST MINE DISASTER in America, and one of the worst in the history of coal mining, occurred in the Monongah mines of the Fairmont Coal Co. at Monongah W. Va., on the morning of Dec. 6. It was a tremendous explosion, either of dust or of gas from a suddenly opened pocket. The whole workings of Mines 6 and 8 were wrecked The explosion occurred about 10 a. m., when a full force of men was in the mine; practically all of them were killed. The ventilating fans were blown out of the mine and thrown hundreds of feet away, but during the same day a large fan was secured from another colliery and started to work. The dense afterdamp made rescue work slow and dangerous for two days, and by the time this condition was relieved the work was interrupted by an extensive fire in the mine, fanned by the air blown in by the fans. The fire was brought under control on Dec. 9. Up to the morning of Dec. 10 less than 100 bodies had been recovered. The total dead will probably number 400 or more.

THE COLLAPSE OF A PARTIALLY COMPLETED bridge across the Susquehanna River at Mifflinville, Pa., on Dec. 10, resulted in the death of at least seven workmen and the injury of about 20 others. Owing to the heavy rains of the past few days, together with the snowfall of last week, the north branch of the Susquehanna, upon which the bridge is situated, was rising in flood on the day of the accident at the unprecedented rate of a foot an hour. This flood carried away many small bridges above Mifflinville, and it is thought that the debris knocked away the falsework upon which the bridge was being erected. Exact details of the cause of the disaster are not yet available.

BURNING WATERPROOFING IN A TUNNEL endangered the lives of a dozen workmen recently on the Pennsylvania R. R. extension across the Hudson River into New York City. The new line pierces the southern end of the Palisades by the Bergen Hill tunnels, a pair of single-track rock tunnels about 6,000 ft. long (Eng. News, Dec. 13, 1906). In the west or Hackensack end of these tunnels the felt-and-pitch waterproofing caught fire about 4.30 a. m., Dec. 5, at a cross-passage, and the fire burned up a length of this waterproofing in both tunnels, producing large volumes of smoke. Seven men were taken to the hospital, but all recovered in a few days. The fire also did some little damage to the gantry and the concrete forms. Work was resumed with a day's interruption.

A SPEED OF 36 KNOTS AN HOUR was attained on Dec. 6 in an official trial by the British turbine torpedo-boat destroyer "Tartar" over a mile course. During a two hours test the vessel maintained a speed of 34.7 knots an hour. The "Tartar" is one of a fleet of destroyers the contract for which calls for 33 knots per hour. She is 270 ft. long, has a draft of 8 ft., is of 14,500 HP., and burns oil exclusively as a fuel. Previous to her trials the record for boats of her class was held by the sister ship, "Mohawk," with a mean speed of 34¼ knots per hour for six hours and a maximum of 34½ knots per hour.

THE "MAURETANIA," on her first eastward voyage, lowered the eastbound transatlantic record from Sandy Hook to Daunt's Rock by 21 minutes. Her time for the voyage was 4 days, 22 hrs., 29 min., the length of the eastbound course being 2,807 nautical miles. The previous record was held by the "Lusitania."

By no means the least advantage of the rapid transatlantic service given by these two vessels is that of prompt mail facilities. On this last voyage of the "Mauretania," her mails were delivered in London in time to be answered by vessels leaving for America on Saturday. This means that a letter may be mailed in New York City on one Saturday, and its reply mailed in London in time for the next Saturday's boat out of Liverpool, reaching New York for delivery on the following Friday, or possibly sooner.

PANAMA CANAL WORK DURING NOVEMBER fell slightly below that for October in totals, but on account of the fewer number of working days the daily average of the latter month is higher than ever before. The records for October and November are summarized as follows:

	November.	October.
Excavation, steam shovels:	Cu. Yds.	
Culebra	778,860	826,891
Gatun	162,622	177,013
Mindi, Chagres and La Boca	92,237	73,813
Dredging:		
Colon	417,297	409,632
La Boca	365,423	357,122
Total from canal prism	1,816,439	1,844,471
Accessory works outside canal prism	22,047	24,258
Total excavation for November	1,838,486	1,868,729

For the 24 working days in November the daily average total excavation equalled 76,600 cu. yds. against a daily average of 68,314 cu. yds. for the 27 working days in October. The rainfall in November was 10.73 ins. against 17.1 in October.

THE NOBEL PRIZE in physics is to be awarded to Prof. A. A. Michelson, Professor of Physics at the University of Chicago, who has become well known through his work on the velocity of light and kindred subjects. Prof. Michelson was born in Germany and came to this country while very young. He graduated from the United States Naval Academy in 1873, but left the Navy in 1881. The Nobel prize in chemistry is to be awarded to Sir William Crookes.

THE INCREASE IN GOLD AND SILVER production in the Transvaal, during the last 6 years, is strikingly shown in a table in a recent statistical report of the Transvaal Mines Department. The regularity of the rate of increase in gold production since the close of the Boer War, is particularly striking. We give the output figures below, with the approximate values in American currency:

Y'r end'g June 30.	Gold Output, Fine Oz.	Value.	Silver Output, Fine Oz.	Value.
1902	891,990	$18,414,400		
1903	2,372,076	48,969,000	280,997	$142,000
1904	3,475,311	71,744,200	406,677	219,200
1905	4,322,577	89,235,200	476,086	263,500
1906	5,199,935	107,347,400	574,486	343,600
1907	6,273,577*	129,511,500	679,509*	427,300
Total	22,535,475	$465,321,700	2,417,755	$1,395,600

*Subject to adjustment of balances.

AN ELECTRO-MECHANICAL TRACK BRAKE, the invention of Mr. A. W. Maley, assistant engineer in the tramway department of the Leeds Corporation, Yorkshire, England, is described in the London "Electrician" of Nov. 29. The brake is in effect a combination of slipper blocks in front of and behind a powerful electro-magnetic brake, all three blocks of each set acting on the track and not on the wheels. The magnetic brake is linked to the slipper blocks so that its descent onto the track causes them also to make contact with the rail. The magnetic brake is operated with current from the motors, (running as generators) or it may take current from the trolley circuit. The whole brake combination may be operated manually from the driving platform by suitable levers and links. Two heavy double-deck cars, with top covers, were equipped for tests on the Rodley Hill, Leeds. The gradients on which the trials for high speed stops were made, were 1 in 8.42 and 1 in 9.60. High speed stops with the brakes energized by the motors alone were made at speeds from 19 to 30 mi. per hr. With the car running at such speeds and with six passengers aboard stops were made in less than 250 ft. With the brakes drawing current from the trolley circuit the car was stopped in less than 130 ft., from an initial speed of 18 mi. per hr. Under poorer rail conditions that distance had been increased to 238 ft. The cars were allowed to coast down grade at speeds up to 10.3 mi. per hr. and were stopped whenever desired by manual operation of the track brakes. It was shown that the brakes are practically non-skidding. It is stated, that, in attempting to skid the wheels with the car traveling at high speeds on a heavy grade, they could be made to slip only momentarily before commencing to roll again, and this did not affect the retardation of the car.

PERSONAL.

Mr. A. S. Meldrum, General Superintendent of the Rio Grande Southern Ry. has resigned and the office has been abolished.

Mr. W. H. Elliott has been appointed Engineer of Signals of the New York Central & Hudson River R. R., with jurisdiction over all divisions excepting the electric zone.

Mr. F. W. Schultz has been appointed Master Mechanic of the Missouri Pacific Ry. and St. Louis, Iron Mountain & Southern Ry., at McGehee, Ark., succeeding Mr. I. T. Johns, resigned.

Mr. George S. Blanchard has associated himself with the Carbolineum Wood Preserving Co., of New York, and will make his headquarters at the New York office, where he will have charge of the timber-treating processes of the company.

Mr. R. O. Jones has been appointed Chief Engineer of the Dayton Hydraulic Machinery Co., of Dayton, Ohio, and assumed his duties on Dec. 2. For the past 9 years he has been associated with the Jeanesville Iron Works, of Hazleton, Pa., and for several years was their Chief Engineer.

Mr. G. A. Goodell, General Superintendent of the Chicago Great Western Ry., has resigned to accept a similar position on the Great Northern Ry. Mr. Otto Cornelisen, formerly Superintendent of Transportation, succeeds Mr. Goodell as General Superintendent of the Chicago Great Northern.

Mr. Carl C. Witt has resigned as Assistant Engineer in charge of the construction of the Missouri River bridge at Pierre, S. Dak., for the Pierre & Fort Pierre Ry. He will occupy the position of Chief Engineer of the South Dakota Railroad Commission, with headquarters at Sioux Falls.

Mr. B. C. Rich, Chief Engineer of the Chicago, Indiana & Southern R. R., has resigned and formed a partnership with Mr. A. T. Carlson and Mr. Robert Fife under the name of Rich, Carlson & Fife, General Contractors; with offices in the Fort Dearborn Building, Chicago. Mr. R. B. Seymour has been appointed Chief Engineer of the C. I. & S. R. R., to succeed Mr. Rich.

Mr. Theodore P. Shonts has been elected President of the Chicago & Alton R. R., succeeding Mr. S. M. Felton. We noted Mr. Felton's change to the Mexican Central Ry. in this column last week. Mr. Geo. H. Ross, Second Vice-President and General Manager of the Toledo, St. Louis & Western R. R., was elected Vice-President of the Chicago & Alton, and, it is understood, will be the active head of the road, with headquarters at Chicago; Mr. Shonts will remain in New York.

Mr. Geo. Sanzenbacher, Engineer and Superintendent of the Water Department of Newark, N. J., completed a quarter century of service with the Newark Water Department this month. Mr. Sanzenbacher is a native of Wurtemberg, Germany, and was for some years connected with the Wurtemberg Department of Public Works. He was later in the Engineering Department of Public Works of Stuttgart, and prepared the drawings showing the municipal water-works of Stuttgart for the Berlin Exposition of 1882. In the same year he came to the United States and was engaged as Assistant in the Engineering Department of the Newark Aqueduct Board. He has been continuously in the service of the Newark Water-Works since then, becoming Engineer and Superintendent of the Department in 1905.

Obituary.

Charles Sumner Horton, President of the Susquehanna & New York R. R., and of the Central Pennsylvania Lumber Co. also, died on Dec. 4 at the age of 44.

E. G. Wagner, a locating engineer for the past 20 years in Mexico and the Central American republics, died in camp near Villa Juarez, State of Peublo, Mex., on Nov. 13.

Morris Franklin Tyler, President of the Southern New England Telephone Co. and formerly Treasurer of Yale University, died at his home in New Haven, Conn., on Dec. 4. He was born there in 1848. His first connection with the telephone business was in 1878, and in 1883 he became President of the company mentioned.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. December 12, 1907.

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EDITORIAL.

Technical Works in Public Libraries.

Outside of the collections of a few technical societies and schools, the attention paid by libraries to scientific books is far below that required by their importance. When the average engineer has need for study out of the ordinary line of his work the necessary limitations of his own library, consisting probably of the standard works of the profession, with a few extra treatises on his own specialties, force him to have recourse to the public library. Here usually the insatiable demand for popular fiction makes such a drain upon the funds of the institution and the time of its employees that the few technical books which are on the shelves are poorly classified and hard to locate.

In view of this state of affairs in most cities, it is pleasing to note that the Public Library of the District of Columbia has recently opened a special room, to be devoted entirely to subjects of interest to engineers. In this room, on open shelves, will be placed all the available books and periodicals treating of the useful arts and sciences, from the highest technical works used by the directing engineer to those on the more practical sides of the technologic trades. Not only are those books which the library already possesses placed for use, but special effort will also be made, by consultation with the current trade lists, bibliographies and book reviews, to keep the collection well up with current practice. In addition, serious consideration will be given to all applications from readers for books not in the library and, in so far as funds will permit, such works will be purchased.

A special department of the room is to be taken up entirely with the trade catalogs of various manufacturers. To make this as complete as possible it is urged that all firms issuing catalogs or other trade publications forward copies of such pamphlets to the library, where they will be recorded, classified and shelved.

If our memory rightly serves us, somewhat similar efforts to provide technical books suited to local needs have been made by the Public Library of Newark, N. J. The object at Newark has been to make available printed works dealing with the industrial arts practiced in that city.

Doubtless other wide-awake librarians are meeting the local needs of engineers and artisans in much the same way as has just been noted. Collections of trade catalogs at the Public Library of Providence, R. I., were mentioned in the issue of this Supplement dated April 14, 1904, and in the issue for May 19, 1904, there was published an interesting letter from Dr. John S. Billings, Director of the New York Public Library, relating to a collection of 30,000 trade catalogs in the Astor Branch. Dr. Billings then desired, as doubtless he still does, to receive trade catalogs, as issued, from all classes of manufacturers.

Manufacturing concerns generally would do well to remember that the public libraries of New York, Washington and Providence desire to put trade catalogs on their shelves. It would, we presume, be worth while for manufacturers to ascertain by correspondence whether the public librarians of other important cities are also collecting such catalogs.

This seems a fitting place to note that the New York Public Library is now publishing in its monthly bulletins a list of works, on its shelves, dealing with Hydraulic Engineering. Important articles in the technical press are included. The list, which bids fair to run to a hundred large octavo pages (double-column) will finally be issued as a separate pamphlet.

All such efforts as have been noted in the foregoing paragraphs are highly commendable and due appreciation of them should be shown in every possible way by engineers and manufacturers alike.

Discontinuance of the "Technolexicon".

A simple official announcement, sent out over the signature of T. Peters, director (manager) of the Verein Deutscher Ingenieure, to collaborators in the preparation of the "Technolexicon," chronicles the untimely end of that ambitious undertaking:

> The Society of German Engineers has resolved to discontinue the "Technolexicon" because the work has turned out to be expensive beyond all expectation, and because the costs requisite for its accomplishment within the allotted time exceed the pecuniary means available by the society for this purpose.

At the annual meeting of the society, last summer, the matter of the "Technolexicon" was brought up, we understand, and for the first time an intimation was given that the success of the undertaking was in doubt. No discussion of the matter was published in the society's journal, the "Zeitschrift des Vereines Deutscher Ingenieure," so that the situation and the full reasons for abandoning the enterprise are not known to the public.

The "Technolexicon" is the largest thing yet undertaken by the German society. In a sense it might be called the most important, for an international dictionary of engineering terms is equal in importance to a universal encyclopedia or library of engineering arts and sciences. The latter is not in existence and not in prospect. The present event seems to put the former out of prospect also. Both would labor under the very great disadvantage of requiring very frequest revision and supplementing, or else becoming antiquated very quickly. The advances in engineering are constantly going on, and they are more extensive than might be imagined at first thought.

The need for a multilingual or translating dictionary is something distinct from the need for a dictionary pure and simple. One serves for putting on record in much detail the literary building-blocks of one language; the other is a book of interchange and comparison between those of different languages. The latter is a convenience, or perhaps a necessity, where two languages come in contact; but it does not define or establish anything about either language. The dictionary of a given language, on the contrary, is fundamental and primary; it constitutes a codification and authoritative record of that language. A translating dictionary can be constructed from the dictionaries of the several languages, but the reverse is not possible. The need for dictionaries in each of the civilized tongues is therefore far ahead of the need for a translating dictionary.

It happens that engineering dictionaries exist in not one of the chief languages of civilization, so far as we know; that is, none drawn up with the labor, care and knowledge that such a work demands. Thus the construction of a multilingual technical dictionary at the present time requires substantially the construction of complete technical dictionaries of the several languages covered. That task represents an excessive amount of labor, and labor done under the disadvantage of being done from the exterior of all but one of the component languages. Is it not unreasonable to expect a German, or French, or Danish authority to compile a meritorious English or an Italian technical dictionary? It is equally unreasonable to expect that in the absence of English and Italian technical dictionaries a German worker could construct a good translating dictionary including these languages.

From our point of view, a technical dictionary in the English language is a prior need to any translating dictionary. At present the standards of technical terminology are the text-books and periodical publications which record the progress of engineering work. A few exceptions can be found, where terminology has been fixed by a society or a conference or the like, but these are of vanishing moment, when compared with the whole field. Under the circumstances, it is perhaps surprising that our terminology should be so unified and specific as it is. But the fact that it is so offers no argument against the need of a comprehensive dictionary compilation of the engineering division of the English language. Let us trust that a capable authority may be found, some time in the future, to undertake the great task.

The Number and Excellence of German Technical Books.

The remarkable performance of the German nation in producing technical books is perhaps in some way at the bottom of their having ventured to undertake the "Technolexicon." Whether or not this is true, however, the fact remains that, both in quality and quantity, the German output of technical works commands admiration. It is a safe estimate that twice as many technical books are published in Germany as appear during the same period in the United States. And in the matter of excellence, while we would not venture a specific estimate, the German product can with all assurance be classed as fully the equal of the American. A glance at the reviews of new German books in this or any previous issue of the Engineering Literature Supplement will furnish evidence for these statements. Moreover, not all the current German productions reach this office, though the proportion sent us is a surprisingly large proportion of the total, considering the extent to which the literary interests of the two—America and Germany—are distinct from each other. Publishers of technical books abroad are evidently alive to the advantages of publicity even in countries where they can expect, at best, a very small sale.

The common explanation of the fact that German book productions are so numerous, so thorough, and in general so excellent, is that the

German mind has peculiar aptitude for compiling, analyzing and other functions that are needed for encyclopedic literary work. This is the sort of explanation that evades the difficulty rather than overcomes it. There is plenty of aptitude for analytical study and for thorough investigation in the United States, and notably so in England, sufficient to provide for the writing of far more technical books of high grade than actually appear in these two countries. It may be, however, that the stimulus toward book-writing in England or here is not equal to that in Germany. This would lie to a large extent in the money rewards that come to the producer of a good book, and in turn the size of these rewards depends on the extent of sale which a good book may expect. In the United States, we know, the writing of technical books is not a road to wealth; quite the opposite. The cases are relatively rare in which an author of even a high-grade engineering work secures sufficient remuneration to pay a moderate wage for the time he spent in writing it; sales are not large; the engineering public is anything but an extravagant buyer of books. As to conditions in England or Germany, we are unable to speak with full knowledge. The prices asked in those countries for technical books are lower, it is true, but only in appearance; when compared with the prevailing rates of earnings and expenses they compare closely with the prices asked by American publishers. Larger sales, if they are a fact, must therefore be due to a more universal tendency to buy books, a desire of each person to collect a good personal library. Such a tendency would not only increase the author's direct remuneration by producing larger sales, but would operate to give him greater repute and other incidental compensation for his work.

We heard, recently, another explanation, given by a man familiar with German technical works and to some extent personally familiar with German conditions. He suggested that the large number of technical men in governmental employ in Germany constitutes a class of engineers with a much smaller proportion of fixed duties and a larger proportion of free time than is found, say, in the United States. Many of these men find a natural outlet for their residual activity in writing books, pamphlets, articles and the like; the larger output of excellent technical books is a natural result. This is a plausible explanation. Its only difficulty is that it does not help to explain the large proportion of mediocre or quite impossible book manuscripts presented to American publishers of engineering works, not to mention the considerable number of low-grade books actually published.

REVIEWS.

Hydraulics.

Reviewed by GARDNER S. WILLIAMS,* M. Am. Soc. C. E.

HYDRAULICS.—By S. Dunkerley, D. Sc., M. Inst. C. E., M. Inst. M. E., Professor of Civil and Mechanical Engineering in the University of Manchester and Director of the Whitworth Laboratories. In Two Volumes. Vol. I. Hydraulic Machinery. London, New York and Bombay: Longmans, Green & Co. Cloth; 5¼ × 8¼ ins.; pp. 343; 269 illustrations in the text. $3, net.

RIVER DISCHARGE.—Prepared for the Use of Engineers and Students. By John Clayton Hoyt, Assoc. M. Am. Soc. C. E., Engineer in Charge of Hydraulic Computations, U. S. Geological Survey, and Nathan Clifford Grover, Assoc. M. Am. Soc. C. E., Assistant Chief Hydrographer in Charge of River Measurements, U. S. Geological Survey. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 137; 7 plates and 24 text illustrations. $2.

In the preface to his Hydraulics, Prof. Dunkerley states that the notes from which the book is developed "were written at the Royal Naval College, Greenwich." A second volume will treat of the Resistance and Propulsion of Ships.

The initial volume comprises seven chapters, the first of which, entitled "The Flow of a Perfect Fluid," presents its subject in an excellently concise manner, with almost no references to collateral sources.

Chapter II. deals with "Fluid Friction." It begins with the influence of viscosity, and then considers the critical velocity. The exponent of V for a lead pipe 0.4-in. in diameter is developed from experiments to be 1.807, by the logarithmic method, but the author finally adopts the Fanning expression, $h = \frac{4fl}{d} \cdot \frac{v^2}{2g}$, and computes the value of f from the results of the work of Darcy, to whom he refers as D'Arcy, thereby demonstrating quite clearly that he has not gone back to the original sources for his information. He would probably object strenuously to an equally possible disgurement of his own name. In this chapter the influence of the size of nozzle at outlet on the discharge through a long pipe is put into a mathematical form, and the efficiency expressions for hydraulic power transmission are developed. The solution of cubic equations by the graphical method is then introduced. Obstructions, enlargements, curves, etc., are treated by the usual methods, the jet pump (the author calls it "propeller") is described, and the Flow in Rivers and Canals is taken up, the old Darcy and Bazin formula being presented. The Kutter formula is described, and while the author has been so precise as to present the name Ogani Ganguillet he combines with it the lone surname of Kutter, misspelled as "Kulter." The Venturi meter is described as the invention of Mr. "Charles" Herschel. Water meters, mainly of English types, receive considerable attention, though just why their discussion should have been interposed between the velocity curve in an open channel and Thomson's Theory of River Bends is not apparent to the casual reader. Following the last-named subject the testing of current meters is described, and then the experiments of Mr. Alexander on bends in pipe are abstracted at considerable length. On the flow through a pipe of variable diameter, some experiments by Professor Reynolds are introduced, as well as the results of others on the lines of ship models. The chapter closes with a tabulation of experiments made at Manchester University, upon an enlargement of a pipe from a diameter of 0.65-in. to 2.15 ins.

Chapter III., "Hydraulic Pressure Machines," begins with a consideration of the "Relative Advantages of Using Steam and Water," and is followed by uniform flow and harmonic motion leading up to the problem of the separation of the piston and the water. Hydraulic accumulators, riveters, lifts, gunbrakes, buffers, presses, engines, and cranes complete the chapter.

Chapter IV., "Reciprocating Pumps," deals not only with the theory of such machines, but also with air chambers, hydraulic governors, rams, and the Gutermuth valve. Data, from the manufacturer's circular, of comparative tests of this valve and those of ordinary type are given.

Chapter V., "Simple Machines—Turbines," takes up the impulse or tangential wheel, vane design, Barker's mill, and European turbines. The Jonval is referred to as the "Jouval," and the American mixed flow wheel is discreetly omitted.

Chapter VI., "Centrifugal Pumps," discusses also the Reynolds Hydraulic Brake, the treatment being, however, rather unfinished.

Chapter VII. is devoted to Professor Reynolds' Researches on Flow in Pipes and on the Theory of Lubrication, and for those not having access to the "Transactions of the Royal Society," this chapter is worth the price of the book, if the loose methods of citation and proof-reading which are apparent elsewhere have not vitiated the material it contains.

The volume closes with a collection of sixty-six examples.

The material in the book appears all to have been compiled from British sources and no citations from authors outside of the British Isles are given. The presswork is good, and the illustrations are better than the average English product.

Hoyt and Grover's "River Discharge" is largely a compilation of the methods of measuring stream flow in vogue with the U. S. Geological Survey. The authors state in their preface that "in the preparation of this book there has been brought together from all available sources information in regard to the best practice in this work." As the "Lowell Hydraulic Experiments" is now out of print the authors will have to be pardoned, on that score, for omitting the only accurate formula for rod-float gaging, and one that permits the rod float to rank next to the weir in accuracy for open-channel measurement. If the above work is not available to the authors at the time of their first revision they may refer to Frizell's "Water Power," page 486.

After an historical and general introduction, precipitation, evaporation and run-off is presented. This discussion is the most satisfactory elementary treatment of the subjects named with which the writer is familiar, and the authors and the public are to be congratulated upon its production.

Chapter III. is devoted to descriptions of instruments and equipments used in stream gaging. The construction of rod floats from wood poles weighted with sheet lead is a valuable field practice that is not mentioned, the much more frail tin tube being the form described. No formulae for the reduction of rod-float observations are given.

"Velocity-Area Stations" is the title of Chapter IV., in which the considerations preliminary to their selection and establishment are well presented. A discussion follows of the vertical velocity curve and methods of finding the mean velocity therein. Here again the Francis formula is of great value, but has unfortunately been omitted, and the authors do not appear to appreciate the influence of the character and conformation of the bottom or the effect of curvature on the velocity-distribution curve in following reaches. Tables of gagings are presented, showing a high degree of accuracy for the $^6/_{10}$-depth method, but unfortunately the numerous cases where the method has failed are omitted and the reader is left with an exaggerated idea of the current-meter work done on this system. Instructions for current-meter gagings are given, but the very useful "hand test" is omitted. Various methods of reduction of observations appear, but none of them deal with the determination of the discharge in that portion of the stream below the lowest meter position. A section on float measurements is rather incomplete and gives evidence of a lack of experience on the part of the authors. "Slope Measurements" by means of Kutter's formula are then considered, and in a section devoted to "Measurement of Ice-Covered Streams" many interesting data are presented on the subject, which until recently has been very imperfectly understood.

Chapter V. deals with "Weir Stations" and

*Professor of Civil, Hydraulic and Sanitary Engineering, University of Michigan, Ann Arbor, Mich.

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the formula and methods of computation applicable thereto.

The "Discussion and Use of Data" takes up the "computation of daily discharge" and conditions influencing it, and forms a well-written chapter, which also includes a section on the "Accuracy of Stream-Gaging Data," and one on "Duration of Flow and Horse Power." The section last named might have been improved by the inclusion of the construction and use of the ordinary mass-diagram. The chapter closes with an enumeration of Sources of Stream-Gaging Data.

The book is concluded by a series of tables on weir discharge for the Francis formulae, with and without end contractions, Horton's formula for broad crests, and Bazin's formula, and tables of multipliers for irregular weirs, to be applied to the Bazin discharges, similar to those given in Williams and Hazen's "Hydraulic Tables," a table of 3/2 powers from 0 to 12 by hundredths, and various conversion tables appertaining to the subjects treated in the text.

Being practically the only work available dealing with its subject this volume will find a ready reception, and when future editions enable the authors to fill in the omissions and strengthen the weak spots, it should be one of the most valuable works on practical hydraulics printed in the English language.

A Text-Book on Reinforced Concrete.

Reviewed by LEWIS J. JOHNSON,* M. Am. Soc. C. E.

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION.—By F. E. Turneaure, Dean of the College of Engineering, University of Wisconsin, and E. R. Maurer, Professor of Mechanics, University of Wisconsin. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5½ × 9¼ ins.; pp. 317; 130 illustrations, mostly in the text. $3, net.

The authors of this work state that their purpose was "to cover in a systematic manner those principles of mechanics underlying the design of reinforced concrete, to present the results of all available tests that may aid in establishing coefficients and working stresses, and to give such illustrative material from actual designs as may be needed to make clear the principles involved." The task was one well worth undertaking, and, it is a pleasure to add, it has been done admirably.

About three-quarters of the book is devoted to development of methods of design and the remainder to very condensed descriptions of recent American constructions in reinforced concrete. The general scope and balance of the work is not very different from Mörsch's Eisenbetonbau, and it is no doubt destined to perform for English-speaking engineers much the same valuable service which Mörsch has rendered the Germans, Swiss and Austrians.

The authors were wise in restricting their field as they did. The result is satisfactory, accordingly. They have presented a consecutive, consistent treatment of design, such as will appeal to anyone well trained in the fundamental principles of resistance of materials. They wisely have not presented a museum of all the various attempts, good, bad and indifferent, which have been made in the past fifteen eventful years. Accounts of such attempts are only too easily available in the existing books and trade literature. The authors have made a concise presentation of the best fruits of investigation to date, and it is gratifying to be able to believe, as the reviewer, at least, does, that there is little in the book which future developments are likely to invalidate. The changes which future editions will have to chronicle will lie, probably, in the domain of elaboration in the design of web reinforcement, footings, "circular plates" and other obscure subjects, or in the domain of coefficients and working stresses, or details. The book could hardly have been written two or three years ago, and by appearing now, it is commendably prompt on the heels of the possibilities.

The treatment throughout is sane and conservative: some may consider it a little too conservative in parts, but real friends of reinforced concrete will not take this conservatism amiss, and the reviewer, speaking for himself, would not care to see any great change in this respect at present. The progress of the art, especially in the direction of a more liberal use of cement, seems likely soon, if not already, to justify higher working stresses than 300 to 400 lbs. per sq. in. for compression in columns and 500 to 600 lbs. in beams—the figures stated by the authors for "1:2:4" to "1:2½:5" concrete. For columns, richer and more rationally proportioned mixtures with correspondingly higher working stresses are undoubtedly a well marked and justifiable tendency in present practice.

The methods of computation for beams and columns are properly based on the now almost universally accepted principle of linear distribution of stress with no reliance on tensile strength of concrete except, of course, to resist diagonal tension in beams. The methods in general are in harmony with the best German practice, even to the use of 15 for the ratio of moduli of elasticity. Due attention is also given to Prof. Talbot's and other parabolic distributions.

The treatment of the difficult subject of web stresses and web reinforcement is perhaps the best thus far available in English, but the insufficiency of experimental data upon this subject is still sadly felt, a fact which the authors might well have emphasized more strongly than they did. One wonders that no exposition is made of Mörsch's work and ideas on this subject, which are the basis of the best continental practice and almost unknown among English-speaking engineers. They are a natural outgrowth of the same principles from which Professors Turneaure and Maurer proceeded, and include most interesting tests of Mörsch's ideas as exemplified in large T-sections.

It is gratifying to observe the large number of numerical examples. They would be even more effective if they were not so crowded in the type setting, and in some instances the numerical work and explanations might well be fuller. There is little danger of overdoing fulness in a numerical example, and insufficient fulness may often be fatal to the complete and vigorous comprehension of an exposition which one has a right to hope to gain from such an example.

The treatment of the reinforced concrete arch is commendable, and sweeps away in a most refreshing manner much of the cloudiness usually besetting that subject. It includes clearly worked out numerical examples.

There is a fair index. The misprints are few for a first edition, and the publishers' part of the work is good.

Apart from such points of minor detail as have been mentioned above, it is difficult to see how, in the present state of the art, a better and safer exposition could have been made, and the task was not a small one nor the dangers few. The book will be found indispensable by all workers in reinforced-concrete design.

The authors have performed a distinct service to the profession, and are to be congratulated upon their success.

*Professor of Civil Engineering, Harvard University, Cambridge, Mass.

Fire Assaying.

Reviewed by BRADLEY STOUGHTON.*

A MANUAL OF FIRE ASSAYING.—By Charles Herman Fulton, E. M., President and Professor of Metallurgy in the South Dakota School of Mines. New York and London: Hill Publishing Co. Cloth; 6 × 9½ ins.; pp. 178; 44 illustrations in the text, and numerous tables. $2.

This is undobutedly the best book upon the fire assay for gold and silver, as well as the most scientific discussion of the subject, that has yet been produced. It gives all the data necessary to teach the subject to students or beginners, or to assist an experienced man in running an office, including keeping the instruments and apparatus in the best order, handling large amounts of work per day and new or unusual ores, and making such corrections in the work as will give the highest degree of accuracy. It is written in a clear and easy style, which is less tiresome to read than most treatises of so technical a character. The illustrations are well selected and sufficiently abundant to make the descriptive text brief, clear and interesting. The references to other authorities, in which one may study more fully each of the different questions discussed, are very complete, and the data are well chosen and well presented, so as to be capable of being understood even by a man without technical training, with occasional help from his superior upon the chemical notations and calculations involved. The index is as complete as the great majority of indexes to scientific books, but it falls far short of what it should be. Doubtless the writer and publishers of this book believe that it will be referred to by thousands of busy men every year; if so, the few extra dollars that it would cost to make the index absolutely complete would be money very well spent. This is not offered as an indictment against this book in particular, but against practically all of our technical treatises, not only in English, but in German as well. A single example will serve to illustrate: On page 41 of this book is a very useful little paragraph headed "The Assay-Ton System." This is not referred to in the index under "Assay," "Ton," or "System," but is referred to under the head of "Weights." The reviewer does not deny that this is a logical classification, but there will certainly be many men who, reading the book over, will remember the paragraph headed in this way, and will attempt to look it up in the index at some future time, under one of those words. If all technical books would increases their indexes by 50%, and many of them by 400%, the world would be a great gainer through saving the time of its busy men. The producers of scientific books really owe this consideration to their readers.

This book deals principally with the assay for gold and silver, but there is a good chapter on

*Adjunct Professor, Department of Metallurgy, Columbia University, New York City.

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the assay for platinum and its associated minerals, and a total of nine pages devoted to tin, mercury, lead, bismuth and antimony. The chapter on "Errors in the Assay for Gold and Silver" is very good and deserves special mention, even in this excellent treatise.

TABLES OF QUANTITIES FOR PRELIMINARY ESTIMATES.—By E. F. Hauch and P. D. Rice. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4 × 6¾ ins.; pp. 92; 5 figures in the text. $1.25; English price, 5s. 6d., net.

In a review of twelve different sets of tables for the computation of earthwork quantities which we published in our issue of Jan. 15, 1903, we said:

> From the foregoing view our correspondent will see that there are no tables giving areas for different widths of roadbed and slopes where the ground has a side slope.

Messrs. Hauch and Rice have supplied this needed addition. Their tables give station yardages to the nearest cubic foot, computed from the prismoid formula, for roadway widths from 12 to 32 feet, increasing by arguments of 2 feet, for side slopes from 5° to 35°, increasing by 5°, and heights increasing by units from 1 to 50 feet. (The typography and arrangement are excellent. The only criticism to be made is that there should have been given more complete directions as to the methods of using the tables and a more definite analysis of their mathematical deduction. Such directions and analysis are to be found in any treatment of the theory of earthwork computations, but it would add to the compactness of the volume if they were included therein.

LA TECNOLOGIA DELLE SALDATURE AUTOGENE DEI METALLI.—By S. Ragno. Milan, Italy: Ulrico Hoepli. Boards; 4 × 6 ins.; pp. 129; 18 illustrations in the text. 2 lire; American price, 60 cts.

The various methods of "autogenous welding" are discussed in this little work, with a view to exhibiting their relative usefulness. The available methods are: Electric resistance welding; thermit welding (or casting); welding by high-temperature flame heating, using (a) oxyhydrogen flame, (b) oxyacetylene flame, or (c) a flame of oxygen and illuminating gas. Tension tests of welds made by several of these methods are reported (electric, oxyhydrogen, oxyacetylene). They make a very unfavorable showing for the respective methods of welding, as the results are often zero, always relatively low, and the elongation in all cases is reduced to a negligible amount. Of the three methods tested, the electric seems to make the worst showing, and the oxyacetylene the best.

CAVE E MINIERE.—By S. Bertolio. Milan, Italy: Ulrico Hoepli. Paper; 6⅛ × 9¼ ins.; pp. 708; 204 illustrations in the text. 16 lire; American price, $4.80.

The title "Mines and Quarries" hardly suggests the scope of this work, which represents a descriptive text-book on mining and mining operations. The geology of minerals and mineral deposits, the mechanical processes of the miner and quarryman, systems of exploitation, transportation, drainage and ventilation, and rock-breaking and concentration, are treated in the order named. This is a large volume of matter to cover in a single book, especially as a descriptive treatment is of necessity rather extended. Within the limitations of space thus imposed, the text appears to be reliable and fairly comprehensive. The latter term, of course, must be interpreted with reference to the country for which the book is written, as the variations of practice in the different mining regions of the world give rise to corresponding variations in the relative size and importance of the several parts of the general subject.

A COURSE IN STRUCTURAL DRAFTING.—A Description of Material Used in Structural Design and Drafting Room Practice Relating to Same, with a Few Plates for the Student. Compiled and Arranged by W. D. Browning, Author of "Dimensions of Pipe, Fittings and Valves," etc. Collinwood, O.: The Industrial Magazine. Flexible cloth; 6 × 9 ins.; pp. 64; folding plates and text illustrations. $1.

A considerable portion of the matter here given has been compiled from the handbook issued by a structural steel concern as well as from periodicals. The book is unquestionably useful, but the language of the text is not always happily chosen and is sometimes obscure. Typographical errors abound. The drawings very well illustrate the matter presented; they are in some instances very coarsely executed, however, and have in most cases not been sufficiently reduced in size.

RAILWAY SHOP UP TO DATE.—A Reference Book of Up-to-Date American Railway Shop Practice.—Compiled by the Editorial Staff of the "Railway Master Mechanic." Chicago. Crandall Publishing Co. Cloth; 9 × 12 ins.; pp. 243; illustrated. $4.

A few years ago Mr. Walter G. Berg, M. Am. Soc. C. E., Chief Engineer of the Lehigh Valley R. R., wrote an excellent and competent book upon the principles of railway shop design. The present book deals more particularly with actual practice and examples, and is a compilation prepared by the editorial staff of the "Railway Master Mechanic," from articles which have appeared in that journal. The work has been done with the assistance of an advisory committee, composed of Mr. C. A. Schroyer (Chicago & Northwestern Ry.); Mr. M. K. Barnum (Chicago, Burlington & Quincy Ry.), and Mr. R. D. Smith (New York Central Lines). The title is in the singular, but should properly be either "Railway Shops" or "The Railway Shop." The general arrangement or layout is first discussed, and numerous examples are given, but while comparisons are drawn to a certain extent the treatment is mainly descriptive. Other chapters are devoted to locomotive, blacksmith, freight-car and passenger-car shops, planing mill, foundry, power plant, storehouse and roundhouse. One of the most satisfactory chapters is that dealing with the locomotive or erecting shop, as it presents a number of different arrangements; power distribution for shops is also discussed in this chapter. Detail lists of tool equipment of certain shops are given, although these seem to be of very little use. The chapter on roundhouses is disappointing; it is very short and discursive; the important subject of removing smoke and gases is barely touched upon.

The illustrations are grouped after each chapter, but they are not numbered and are largely independent of the printed matter. The book is printed in large, clear type, and many of the illustrations are also clear. On the other hand, not a few of the illustrations are extremely coarse and black. To the designer of a system of railway shops the book will best serve as supplementary to a previous careful study of Mr. Berg's little book; and it will then serve him mainly as a work of reference showing what methods have been adopted to meet certain ends at individual plants. The book will be of great value in the office of any railway motive-power or shop department officer.

WEATHER BUREAU.—Report of the Chief of the Weather Bureau, 1905-6. Washington, D. C.: U. S. Department of Agriculture. Cloth; 10 × 12 ins.; pp. 405; tables.

Since most of the figures given in this useful report are for the calendar year 1905, and the latest (a few) are for June, 1906, it is fair to inquire why the appearance of the volume should be delayed until December, 1907. The answer, such as it is, seems to be that the Government Printing Office is responsible, since Mr. Moore's letter of transmittal is dated Aug. 30, 1906. A commendable main feature of this report is twice-daily (8 a. m. and 8 p. m.) observations at 29 selected representative stations for every day in the year 1905. These observations include pressure, air temperature, moisture, wind direction and velocity, precipitation in previous 12 hours and cloud and fog observations. For temperature, the maxima and minima for each 12 hours are given, in addition to the 8 a. m. and 8 p. m. observations. Monthly and annual averages of various observations are given for 201 stations, also for the calendar year 1905. Temperature and rainfall figures and rates of first and last killing frosts are given by months for pay and cooperative stations, for the year 1905-6. For a restricted list of stations there are given monthly and seasonal snowfalls, 1905-6; and, for another list of stations, the sunshine in 1905, stated in hours per month and percentages of possible total sunshine. Finally, the report contains a table of excessive rainfalls for more than one hundred stations, grouped by drainage basins. This record shows the accumulated amounts of precipitation for each five minutes during all storms of 1905, in which the rate of fall equalled 0.25-in. in any five minutes or 0.75-in. in one hour, at stations of the Weather Bureau furnished with self-registering gages.

Records similar to the one just noted have now been published for ten consecutive years. Of records prior to those for the ten years named the report states:

> Previous to 1896 the published data consists of a record of maximum amounts of rainfall in 5 and 10 minute periods and also in 1 and 24 hours. The Annual Report for 1895-6 contains a summary of the records which up to that time had been made at the principal stations supplied with automatic gages.

Aside from the general precipitation, these statistics of excessive rainfalls are probably the most valuable records for the engineer published by the Weather Bureau. As to the general rainfall statistics, we regret to note that attempts to secure records for high altitudes have thus far met with little success.

PRINCIPLES OF HEATING.—A Practical and Comprehensive Treatise on Applied Theory in Heating. By William G. Snow, M. Am. Soc. M. E. New York: David Williams Co. Cloth; 5¾ × 9 ins.; pp. 161; 62 illustrations in the text; 7 charts and 38 tables. $2.

A more suitable title for this book would seem to be "Notes on the Theory and Practice of Heating," since the volume is by no means confined to principles, and most of the contents have the fragmentary character of writings reproduced, with little change, from the trade press. Within the limited space available the author seems to have covered his subject, if modified as we have suggested, in a comprehensive and generally satisfactory manner. The book is confined almost wholly to steam and hot-water heating and deals chiefly with the former. The illustrations include both good and bad line cuts and also a number of half-tones. Included in the latter are a considerable number of half-tones of the familiar trade catalog order, some of which appear to be worse for having done service so many times.

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Reviewed by LIONEL S. MARKS.*

TECHNISCHE UNTERSUCHUNGSMETHODEN ZUR BETRIEBSKONTROLLE.—By Julius Brand, Principal of the Royal Mechanical Engineering College at Elberfeld. Second edition, enlarged and improved. Berlin, Germany: Julius Springer. Cloth; 6 x 9¼ ins.; pp. 411; 2 plates and 301 text illustrations. 8 marks; American price, $3.20.

DIE DAMPKESSEL.—A Text-book for Students of Technical Colleges and a Manual for Engineers. By F. Tetzner, Professor in the Royal Mechanical College at Dortmund. Third Edition, improved. Berlin, Germany: Julius Springer. Cloth; 6 x 9½ ins.; pp. 200; 38 plates and 149 text illustrations. 8 marks; American price, $3.20.

The title of the first of these books hardly gives a satisfactory idea of its contents. The subject matter is actually a description and discussion of the instruments and methods used in the investigation of the performance of the various parts of power plants, more particularly of steam plants. The parts of the book which specially merit attention are those descriptive of the instruments used and their methods of operation. In this particular field the book is more comprehensive than any other known to the reviewer. The instruments dealt with are almost exclusively German—but this makes the book somewhat more interesting to American and British readers as it includes a great many instruments which are practically unknown out of Germany. From this point of view the first section, consisting of more than seventy pages, on apparatus for flue-gas analysis, is particularly noteworthy. There has been great activity in Germany in the past few years in the invention of special apparatus for continuously indicating and in many cases for permanently recording the percentage of CO_2 in the flue gases. They work on one of two principles: either (1) by measuring the difference in density between the flue gases and air (both being at the same temperature and pressure) or (2) by automatically taking a certain volume of the flue gas into the apparatus, bringing it into contact with a caustic potash solution and then measuring and recording the decrease in volume which results from the absorbtion of the CO_2. Such apparatus is to be found in practically all the modern power plants in Germany, though it is but little known in this country. The Krell-Schulze apparatus of the first class and the Ados apparatus of the second class are discussed at considerable length—their principle, construction, operation and adjustment being gone into carefully.

The sections on the determination of the heats of combustion of solid, liquid and gaseous fuels and on the determination of moisture in coal, though satisfactorily treated, have nothing that is novel to the well-informed American engineer. Among the methods of determining smoke density, the Kapnoscope is described, an instrument which appears to afford greater certainty in the judging of smoke density than the Ringelmann method, the method most used in this country. The Kapnoscope is a circular cardboard disk, with a hole in the center. The disk is divided into five equal segments which are colored different densities from light gray to black. The observer, with the sun (if there is any) behind him, looks at the smoke through the hole in the disk and compares its density with the densities of the colored segments.

For the measurement of chimney draft a number of instruments of the greatest refinement are described, including the Krell micromanometer, the reading of which can be relied upon to within 1-300-in. of water. Considerable space is given to the various forms of polar planimeter, including the theory of the instrument and explicit instruction for determining its accuracy.

There is one respect in which the book might be made more satisfactory for general use, but that may be too much to expect in view of the general German practice in technical treatment: the treatment is distinctly too diffuse throughout; the author apparently does not consider it his duty to exercise any selective judgment. As an illustration, the otherwise highly satisfactory treatment of indicators may be cited. There is a full discussion of the indicators of Rosenkranz, Schäffer and Budenburg, Thompson, Richards, Crosby, Staus and Maihak, very fully illustrated by some fifty figures, and for most of the makers at least two or three indicators are described, including inside spring, outside spring, gas-engine indicator and continuous paper indicators. There are also full discussions of Hlawatschek's integrating indicator; of Fottinger's torsion indicator, which has been used so largely and with such success for determining the output of marine engines and steam turbines, and of the optical indicator or manograph, which has made a place for itself in automobile practice. Besides this, the calibration of the indicator, hot and cold, by dead weight and by fluid pressure, and the calibrating apparatus built by the various makers, are gone into at considerable length. Perhaps the most interesting part of the discussion of indicators is that given up to the methods of determining the true mean effective pressure of an indicator card when the scale of the indicator spring is found to vary throughout its range. Such corrections are practically unknown in this country, and it is doubtful whether, in view of the numerous sources of error in an indicator card, such refinements of measurement are desirable; but it has certainly become a very general practice for German engineers to correct their indicator cards for the variation of strength of the indicator spring whenever the card is taken for scientific research or for important guarantee tests.

Other sections deal with the methods of conducting tests of steam plants and of working up the results—and with the testing of lubricating oils. The book ends with a useful list of the makers of the various pieces of apparatus described.

The book is a characteristically excellent piece of book making. One never opens a book published by Springer without a feeling of humiliation at the wretched book-making which is inflicted upon us by our leading American technical publishers.

The literature of the Steam Boiler is so voluminous that each author of a new book on that subject is bound to ask himself what he has to offer better than is already available. Professor Tetzner answers that question by declaring his intention of bringing together within small compass all that is necessary for the complete design of a steam boiler plant and also whatever is necessary for determining the choice of the kind of boiler to be used. That he has been successful in his intention is evidenced by the fact that this, the third edition, follows but two years after the second.

Directness, compactness and the practical point of view are the principal characteristics of this work. Whatever there is of descriptive matter is brief and straight to the point—the figures (of which there are 149 in the text, and at least as many more in the folding plates—many fully dimensioned) are adequate, and render fuller description unnecessary. In the design of the various parts of the boiler the formulae (generally taken from Bach's Maschinenelemente) are stated with the utmost precision and all the constants are given with their ranges of application. There is nothing new in the book, but there is brought together in the most systematic, and, at the same time, in a readable manner, all that is necessary for making the ordinary calculations for the proportions and strength of parts of boilers of usual forms.

To the American engineer the striking thing about a book of this sort is the considerable difference which it shows to exist between German and American steam boiler practice. The most common American boiler is the plain multitubular (fire-tube) boiler—but no mention of such a boiler is made in this book nor has the writer ever seen such a boiler in Germany. Similarly, the so-called Elephant boiler—consisting generally of two plain cylindrical boilers lying vertically one above the other and connected together—a type which is in extensive use in Germany, is practically unknown in this country.

A certain amount of conservatism may explain

*Assistant Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.

"I would have given $1,000.00 for this book a year ago."—W. H. BURK, Knoxville, Tenn.

Field System

BY

FRANK B. GILBRETH

M. Am. Soc. M. E.

WHO THE AUTHOR IS.—Frank B. Gilbreth is the contractor who has made the "cost-plus-a-fixed-sum-contract" famous. In order to handle contract work scattered all over North America, Mr. Gilbreth found it necessary to develop a system whereby his foremen would execute work properly, promptly and economically. The code of rules and instructions to his foremen, and the printed forms for their reports, were bound in book form, and this book Mr. Gilbreth called his "Field System." Mr. Gilbreth's contracts have covered the widest possible range. Railways, canals, dams, factories, office buildings, whole industrial towns, are among the works that he has executed.

WHY ENGINEERS SHOULD STUDY "FIELD SYSTEM."—Every engineer should know how to manage men, for, whether he confines himself to purely professional work or enters into business of executing construction work, his ambition should be to direct the men under him in a manner that will secure the greatest possible efficiency. A revolution in the art of managing men is now in progress. Direct personal supervision was once deemed essential. To-day, however "system" is fast supplanting personal supervision. By "system" we mean printed or written directions for employees to follow, and daily reports that show what the employees have done. System of this sort has recently been extended to the field survey work of the U. S. Geological Survey. While Gilbreth's "Field System" is not a system for the management of surveys, for example, it is rich in suggestions that can be applied in the management of any kind of field work, whether employees are engaged in surveying or in construction. Its rules and methods are applicable to office work, in so far as the principles involved are concerned. The book, in brief, is a treatise on the science of managing men by system. No engineer who aims to be more than a subordinate can afford not to have this treatise, written by a man who is an acknowledged adept in managing men.

Hundreds of engineers have gone into the contracting business during the past few years, and there is room for thousands more. But if they are to succeed in any great measure, it must be by the intelligent application of system and cost analysis. Gilbreth's "Field System" does not cover the whole field, nor was it written to cover it, but it does cover a very important part of the field, and a part upon which practically nothing has ever been written.

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the difference of practice in the common forms of steam boilers, but it is somewhat more difficult to account for the divergence of practice in so modern an appliance as the mechanical stoker. The type of stoker most frequently seen in large German power plants (and to which most space is devoted in this book) has a hinged blade which is forced backward through a certain angle against the resistance of a spiral spring. At the end of its travel the blade is liberated and is brought smartly forward by the spring, striking the coal that has fallen in front of it (from a hopper) and scattering it over the fire. As the travel of the blade, and consequently the tension of the spring, are varied systematically by an outside mechanism, the coal can be sent successively to different parts of the grate, making it possible to keep an even fire. This type of stoker, which meets with so much favor in Germany, is practically unknown here—while, on the other hand, the underfeed type of stoker, which has been so successful in this country, is not mentioned at all.

The use of wrought iron plates in boiler construction, which has practically ceased in this country, is still fairly common in German practice. The State regulations as to the strength of iron and steel plates, for boiler use, contain a so-called "quality-figure" for each kind of plate. This quality-figure is the sum of the tensile strength of the plate in kilograms per square centimeter, and the percentage elongation. For instance, fire plates of steel must reach a quality-figure of 62; that is, if the tensile strength is 34 kgs. per sq. in., the elongation must be at least 28%. There is also, of course, a maximum permissible tensile strength.

Besides the matter belonging to the design of boilers the book contains sections on the care of boilers, the purification of feed water and tables of dimensions of special parts. It ends with the complete calculations of six different boilers.

Electric Railways.

Reviewed by HENRY H. NORRIS.*

ELECTRIC RAILWAYS.—Theoretically and Practically Treated. By Sydney W. Ashe, B. S., E. E., Assoc. M. Am. Inst. E. E., Consulting Electrical Engineer, Department of Electrical Engineering, Polytechnic Institute of Brooklyn. Vol. II. Engineering Preliminaries and Direct-Current Sub-Stations. New York: D. Van Nostrand Co. London, England: Archibald Constable & Co., Ltd. Cloth; 5 × 7¾ ins.; pp. 282; 145 illustrations, mostly in the text. $2.50, net.

This is the second volume of a series of three† designed to cover the entire field of electric railway operation. Owing to press of work, Mr. Kelley, of the New York Central R. R. Co., was unable to participate in the preparation of the second volume, as he did in the first. Mr. Ashe states that he expects to have Mr. Kelley's co-operation in writing the third volume. The present volume possesses characteristics similar to its predecessor in that it is largely a compilation of material elsewhere available. This information is arranged in form convenient for reference. Owing to the fact that the scissors are conspicuous in the make-up, there is a certain lack of homogeneity in the treatment, but the author is very careful to give proper credit for all quotations and data. His work is rather that of editor than author, although considerable original text is included. The authorities quoted are excellent, but they are not all in agreement; in fact, some of the papers given aroused violent opposition upon their original presentation. The larger part of the papers were presented before the American Institute of Electrical Engineers.

As indicated in the sub-title, the present volume contains two main divisions. The first comprises the engineering studies which are made before a railway project is undertaken. The second is descriptive of the equipment and operation of sub-stations in which the electric power is transformed from the standard, three-phase variety necessary for transmission, to the direct-current form still used in most railway systems. Chapter I. contains a very readable and elementary study of the relation of railway equipment and earnings to the populations of the communities. This is based largely upon the excellent U. S. Census Bulletin (1902) on Street and Electric Railways. Diagrams and tables are given to show the number of miles of track which a given community can support, the number of rides which each inhabitant will take, the number of cars required, etc. Numerical examples are worked out to show the applications of the principles. Taking a typical city with 31,200 people, the author shows that they can support 22½ miles of track, and that they will pay 2,152,800 fares per annum, producing a gross income of $107,640. To earn this income will require 13 cars, which will make 438,200 car-miles during the year.

Chapter II., on pre-determining motor capacity, is largely a digest of an Am. Inst. E. E. paper by Mr. A. H. Armstrong, of the General Electric Co., who advocates the employment of actual track tests in obtaining the service capacity of a motor equipment. Mr. Armstrong's motor capacity, train resistance and speed-energy curves are given. The remainder of the chapter is a nine-page quotation from a "Street Railway Journal" article by Mr. N. W. Storer, of the Westinghouse Co., advocating a different method for predetermining the proper motor equipment for a given case. Chapter III., which contains still a third method for the same purpose, is a 27-page quotation from an Institute paper by Dr. C. T. Hutchinson, which, when presented in 1902, aroused vigorous and warm discussion. The application of this method is indicated in Chapter IV., which is largely an abstract of a lecture on graphic time-tables by the well-known expert on this subject, Mr. C. O. Mailloux. The chapter also contains a chart prepared by Mr. B. J. Arnold, in his studies preparatory to the N. Y. Central electrification. Chapter V. contains a 13-page quotation from an Institute paper by Mr. C. W. Ricker, on substation location, followed by some load diagrams from the Brooklyn Rapid Transit system. Tables of cost data from various authorities are introduced at this point.

The latter two-thirds of the volume are devoted to the substation and its equipment. The various elements—switches, transformers, rotary converters and instruments—are fully treated from both the structural and operation standpoints. While the information contained is largely available in other convenient forms, it is here arranged systematically and will be read by many who would not take the trouble to consult the original authorities. The author has made a specialty of substation work, particularly the handling of rotary converters. He presented an excellent Institute paper in 1905 on the starting of these machines, which is included in Chapter VI. Chapter VII. is devoted to the construction and theory of rotary converters, the latter being from Hay's book on alternating currents.* A complete set of Westinghouse converter specifications is appended. The transformer is the subject of a short chapter and a still shorter one deals with transformer oils. The latter chapter is based upon two papers by Messrs. C. E. Skinner and S. M. Kintner, of the Westinghouse Co., who are recognized as authorities on the subject. The last chapter, on auxiliary substation apparatus, treats of various devices as follows: Power factor meters, synchroscopes, synchronizers, circuit-breakers, switches, time-limit relays, lightning arresters, rheostats, oscillators and speed-limit devices.

Since the appearance of the first volume of the work under notice, the elaborate work entitled "Electric Railway Engineering,"† by Messrs. Parshall and Hobart has been published. This covers the same field as Mr. Ashe's book, and in a much more thorough manner. The latter has, therefore, a formidable competitor, which was not the case when the first volume appeared in 1905. While "Electric Railway Engineering" is a more expensive work, the difference in price is not great when it is remembered that there will be three volumes in "Electric Railways." Among other recent books in the same field are "American Electric Railway Practice,"‡ by Herrick and Boynton, and "Electric Railways," a reprint of the papers presented at the International Electrical Congress of 1904.

*Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.
†See review of Vol. I., Engineering News, May 18, 1905, p. 532.

*Eng. News, May 12, 1906, p. 430.
†Eng. News, June 13, 1907, p. 663.

‡Eng. News, June 13, 1907, p. 663.

BULLETINS, U. S. GEOLOGICAL SURVEY.—George Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.

No. 323: Experimental Work Conducted in the Chemical Laboratory of the United States Fuel Testing Plant at St. Louis, Mo. Jan. 1, 1905, to July 31, 1906. By N. W. Lord. Pp. 49.

No. 324: The San Francisco Earthquake and Fire of April 18, 1906, and Their Effects on Structures and Structural Materials. Reports by Grove Karl Gilbert, Richard Lewis Humphrey, John Stephen Sewell and Frank Soulé, with Preface by Joseph Austin Holmes, in Charge of Technologic Branch. Pp. 170; 57 plates and 2 text figures.

Bulletin 323 contains the report of 13 experimental investigations (mostly on accuracy) of methods used by the United States Fuel Testing Plant at St. Louis in the testing of coals. It was found that as far as sampling was concerned the analytical work closely represented the average of the carload. The moisture loss of a coarse sample, allowed to stand a short time in the laboratory in covered metal pails, was shown to be unimportant. The results obtained for moisture from the original samples that were ground down without preliminary air drying are decidedly lower than the results obtained from regularly prepared air-dried samples. It is stated that the increase in ash content due to abrasion of the pebbles used in a ball mill for pulverizing samples was inappreciable.

In addition to the results of investigations on accuracy of methods, there are given tentative laboratory methods of determining the adaptability of coals to improvement by washing, and methods of determining the volatile matter in coals and lignites.

Bulletin 324 contains the reports of four expert investigators of the San Francisco earthquake of 1906: Messrs. G. K. Gilbert of the U. S. Geological Survey, Richard L. Humphrey, M. Am. Soc. C. E., representing the Structural Materials Division of the Survey, Capt. John Stephen Sewell, Corps of Engineers, U. S. A., and Prof. Frank Soulé, Dean of the College of Civil Engineering of the University of California. Mr. Gilbert confines himself to the earthquake as a natural phenomenon, and Prof. Soulé discusses the general effects of the earthquake and the fire. The other two experts devote themselves chiefly to the effect of the fire on the important structures of San Francisco.

The report is illustrated by over fifty half-tone plates and by large scale maps. It should be placed in every engineering reference library.

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A German Work on Surveying.

Reviewed by HORACE ANDREWS.*

EINFUEHRUNG IN DIE GEODAESIE.—By Dr. O. Eggert, Professor in the Technical College at Danzig. Leipzig, Germany: B. G. Teubner. Cloth; 5¾ × 9 ins.; pp. 437; 237 illustrations in the text. 10 marks; American price, $4.

This work had its origin in a series of lectures given by the author at the University of Berlin, in 1904. These are now put into book form at the solicitation of the publisher. The author states in his preface that it was necessary to limit the ground covered by the work and therefore only selected methods and instruments are mentioned; the work, however, is sufficiently comprehensive to cover nearly the entire realm of lower geodesy.

During the past year, Dr. Eggert has held the responsible position of scientific editor of the "Zeitschrift für Vermessungswesen," an office for many years filled by the late Prof. W. Jordan, whose "Vermessungskunde" is referred to by the author, in his preface, as a book of the first rank, not only for its thorough exposition of geodetic studies, but also for the complete bibliography which it gives.

The last of the four sections into which the book before us is divided treats of the distribution of errors by the method of least squares, and extends the work beyond the field covered by the original lectures. This section comprises 102 pages, or nearly a fourth of the entire work.

Section 1 treats of the horizontal element of surveys and covers 191 pages. Section 2, of 76 pages, relates to height determinations, while Section 3 treats of surveying for the simultaneous determination of the horizontal and vertical elements (Tachymetry) and covers 69 pages.

Bearing in mind the origin of the book and that it is evidently intended to be supplemented by field practice, it can be regarded as an excellent exposition of the fundamental principles of surveying.

The study of German surveying methods is both interesting and instructive. For lineal measurement the wooden rod seems to be preferred to the steel tape. The mean error of tape measurement is given as exactly double that of rod measurement. The theory of errors of measurement, with the law of their propagation, is referred to in the first section of the book, 14 pages being devoted to that subject.

Trigonometrical work, the three-point problem, forward cuts, traverse lines and the distribution of errors, rectangular coordinates and graphical problems are some of the chief topics of Section 1.

Geometrical, trigonometrical and barometrical leveling are well and concisely treated in Section 2.

In the third section of the book a very complete description is given of the Hammer-Fennel tachymeter, which has been described in the columns of Engineering News. It is in the space devoted to this instrument, whose reputation is yet to be earned, to the rod-planimeter, the "Stereokomparator," the problems of the 6 and 8 points, etc., that this work differs from customary American text books. To stimulate the mind of the student or to arouse his admiration by the elegance of a conception, seem to be regarded as sufficient reasons for including matters that have little practical significance.

Throughout the work many interesting historical facts are noted, and important German treatises on geodetic subjects are referred to frequently. It will be interesting to many to hear that James Watt, the inventor of the steam engine, is accredited by the author, who quotes Hammer as his authority, with being the originator of the method of measurement by stadia. Watt employed this process in preliminary surveys for a canal in 1770.

About twenty pages of the book are devoted to photographic methods and instruments, which are well described and illustrated.

The book is very clearly printed, on sufficiently opaque white paper nearly as thin as that found in the usual pocket field-book. (The entire volume, within its covers, is only 0.6-in. thick.) The diagrams are numerous and well executed, while excellent illustrations of field instruments add very much to the value of the book. The work contains no numerical tables, or index, but has a very good table of contents.

The book is well and concisely written; its chief imperfection is that due to the brevity of treatment unavoidable in a series of lectures. Dr. Eggert's style is so clear that most English students with a small knowledge of German will have little difficulty in reading the book understandingly.

*Civil Engineer, 125 Lancaster St., Albany, N. Y.

SANITATION OF PUBLIC BUILDINGS.—By William Paul Gerhard, M. Am. Soc. M. E., Consulting Engineer for Hydraulic and Sanitary Works. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4¾ × 7½ ins.; pp. 262. $1.50; English price, 6s. 6d., net.

The public buildings here considered are hospitals, theaters, churches and schools. In addition, the various buildings and accessories of markets and abattoirs are taken up. The selection of sites, some of the elements of general design, water supply, lighting, heating, ventilation, cleansing, plumbing, sewage and refuse disposal are the main divisions under which each class of buildings is treated. Fire protection is also given a prominent place. All or nearly all these subjects have been well handled by Mr. Gerhard in one or more of his many earlier books, but the present work, besides its being up-to-date, has the advantage of bringing between two covers the most essential sanitary facts bearing upon public buildings. Bibliographies at the close of each section, except the one on churches, serve as guides to more extended studies of the several classes of buildings. On the sanitation of churches, shameful to relate, there is practically no previous literature. As a manual in the true sense of the word (that is, a compendium of information, in small compass and handy form) the volume deserves commendation. It would serve admirably for the use of boards of health and their inspectors in communities where, for one reason or another, no one is now held responsible for the sanitary condition of public buildings, where the persons so held are not fitted for their trust.

STATE BOARD OF HEALTH OF MASSACHUSETTS.—Report Year Ending Nov. 30, 1906. Boston, Mass.: Pub. Doc. [Chas. Harrington, M. D., Secretary.] Cloth; 6 × 9 ins.; pp 750.

In addition to the usual valuable accounts of the Lawrence experiments on water and sewage purification, and other information on water supply and sewerage, this volume contains a special "Report on the Sanitary Condition of Factories, Workshops and Other Establishments." The report was prepared by the secretary, Dr. Harrington. It deals with about sixty industries, and contains a large amount of useful information. Another useful report by the secretary recounts the results of a large amount of dairy inspection work, carried on in different parts of the State. Finally, we note a lengthy paper by Mr. Stephen DeM. Gage, Biologist of the Lawrence Experiment Station, on the "Significance of the Numbers of Bacteria in Water and Sewage Developing at Different Temperatures." The paper deals with a portion of studies made in the hopes of increasing the value of water analyses by finding some means of quickly and accurately recognizing the different classes of bacteria. As a means to this desirable end, different culture media, different temperatures and a combination of these methods have been tried. The conclusions of the paper indicate progress along the lines stated.

COMMISSIONER OF EDUCATION.—Report for the Year Ending June 30, 1906. Vol. I. (Elmer Ellsworth Brown, Ph. D., Commissioner.) Washington, D. C.: Pub. Doc. Cloth; 5¾ × 9¼ ins.; pp. xlvii. + 643.

Besides various papers on education abroad and at home, this volume contains the usual yearly statistics relating to the schools and colleges of the country. The statistics of agricultural and mechanical colleges are separately given, and the same is true for medical and other professional schools. Considerable information, in very condensed text form, is given regarding "foreign universities and other foreign institutions of higher education."

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Lubrication and Lubricants.

Reviewed by WILLIS E. HALL,* M. Am. Soc. M. E.

LUBRICATION AND LUBRICANTS.—A Treatise on the Theory and Practice of Lubrication, and on the Nature, Properties and Testing of Lubricants. By Leonard Archbutt, F. I. C., F. C. S., Chemist to the Midland Railway Co., and R. Mountford Deeley, M. Inst. M. E., F. G. S., Locomotive Superintendent, Midland Railway. Second Edition, thoroughly revised and enlarged. London, England: Charles Griffin & Co. Cloth; 5¼ × 8¾ ins.; pp. xxx. + 528; 157 illustrations in the text. $6, net.

For a decade past considerable experimenting has been done to determine the laws governing surfaces to which different lubricants have been applied. Many of the results have been published in the Transactions of engineering societies and in engineering periodicals, but the results have been much scattered and their value, therefore, for practical use very much impaired. Messrs. Archbutt and Deeley have rendered a valuable service in the compilation and analysis of much of this information. It is important because it places before the public data which were obtained by and for corporate and individual guidance. For instance, some twenty or more years back it was found by a corporate interest that the serious and costly effects resulting from the free acid in tallow, which was at that time the lubricant used for steam cylinders, could be overcome by the admixture of a large percentage of heavy mineral oil and by rigid specifications as to the permissible percentage of free acid in the tallow. This mixture gave satisfactory lubricating effects and practically eliminated the eating away of the metallic parts. It is almost impossible to estimate the saving resulting from this substitution. But the dissemination of this information was slow and meanwhile some people, learning of it and using it as an asset, bought the components from the refineries, mixed them at a trifling cost and sold the mixture to the unsophisticated, which at that time represented nearly all the smaller consumers of the product. It was put out under some mysterious name and as a secret product at a profit of from 300 to 500%. This remunerative practice was carried on for many years and to a greater or less extent is probably still followed. It is cited as only one of the many ways in which the users of lubricants have been mystified through unacquaintance with their essential nature.

The importance of good lubrication has never been and is not now fully appreciated by the users of lubricants. The loss resulting from its neglect is overlooked by most people. An enormous waste is continually going on through excessive fuel consumption and wear and tear of parts. The use of any lubricant that will keep bearings cool is not, per se, necessarily good practice. Contentment therefrom is very often misleading. Nor is the annual consumption of oil any criterion. It is but a small part of the problem. Take, for instance, the frictional resistances existing in most manufacturing plants employing machinery with its corresponding line shafting. The consumption of power when running light is from 40% to 60%, with a possible few under 40% and probably more over 60%. In other words, an average of 50% of the power delivered by the engines is consumed before any useful work has been done. The figures are conservative. Their magnitude is appreciated better when taken in their aggregate. The best engineering minds are at work trying to squeeze the smallest additional percentage of fuel economy out of engine practice. But of what use is this if through neglect more than the saving accomplished in this way is lost through bad practice between the engine and the point of useful work?

The introduction of electric drive, both direct and through sectional shafting, will assist in the elimination of more or less of this loss, notwithstanding the loss in line through electric transmission, but its influence in the particular field mentioned is, and will be for some time to come, quite limited.

The development of the mineral products and the further study of the fixed oils, together with the laws governing the friction of lubricated surfaces, as evolved by Tower* and Woodbury,† have given us a basis upon which to work. They have shown that the previously accepted theory of friction was wrong—at least when applied to lubricated surfaces.

The principles governing the resistance of lubricated surfaces are simple enough, but it is surprising how little they are understood. They are well treated, and quite fully, in Chapters II., III. and IV. of the book before us. It is true that we do not know the variation in viscosity for varying pressures, nor have we any positive way, excepting through practical tests, of determining absolutely the oiliness of a lubricant; but we do know that the object to be attained is to keep the solids from coming in contact. The lubricant must do neither more nor less. Knowing the unit pressure on a bearing and the velocity, the lubricant that is the correct one for those conditions is sufficient. If it does not accomplish its purpose something other than the lubricant is wrong, but never rectified by the use of a heavier lubricant than should be used for the purpose. Ignoring this point or overcoming other faults in this way cause leaks in the coal pile.

Perfect lubrication is the use of a lubricant of as light a body (viscosity and oiliness) as can be used to reduce the resistance to that between the lubricant and the surfaces of the bearing. That is, it eliminates all friction of solids. It is never attained, but it can with advantage be more nearly approached than in present general practice. Tower's and Woodbury's experiments lead us in the right direction, and if the results as far as obtained by them are closely followed a large part of the waste now going on will be saved. It is not asking for too great a refinement, but for the elimination of a waste that can readily be accomplished. Emphasis is placed upon this phase of the subject to indicate the importance of placing these principles clearly before the users of lubricants.

In regard to the reference to ball bearings, in Chapters IV. and X.: Preference should be given to "Reports from the Central Laboratory for Scientific Technical Investigation," by Professor Stribeck, dated 1900; also to the paper on this subject by Mr. H. Hess, in the Proceedings of the American Society of Mechanical Engineers for June, 1907. (A translation of Prof. Stribeck's report can be found as an appendix to the paper by Mr. Hess).

Chapters V., VI. and VII. discuss quite fully the different lubricants and give a good idea of the development and importance of mineral oils. They also show the limitations of mineral oils, which are especially marked under severe conditions. They give simple and quick methods of detecting adulteration, although this danger is not so prevalent as formerly, now that the subject has been pretty thoroughly threshed out. Purchasing from reputable concerns to specifications can generally be depended upon.

One important feature, and it has been well treated by the present authors, is the influence of free acids in the fixed oils, together with their oxidation and the effect of the free acids upon certain alloys. The emulsion formed by an excess of free acids is very deleterious in many ways and should be avoided whenever the conditions will permit. The chapters on this subject are valuable to users of lubricants who have their own laboratories and who purchase their supplies against specifications.

The "Mechanical Testing of Lubricants," as outlined in Chapter IX., clearly shows the advantage that would accrue to users of lubricants if some method of laboratory test were adopted as a standard. The results could then be reduced to a positive and relative unit. This would be of valuable assistance to the users of lubricants and bearing metals by giving them the value of a product reduced to the same standard for comparison. Under present conditions, the results vary more or less according to the method pursued by the different experimenters. While these have all shown the same general results, this lack of unanimity has placed the details in a somewhat chaotic condition. Much information that can be turned to practical use is contained in this chapter. The viscosity tests given in this chapter should be given preference, by the user of lubricants, to those given in Chapter VI.

Attention is drawn to the results obtained by Clamer*, in Chapter X., and also by Dr. Y.† The latter apply only to one specific case that of railway bearings, where all other conditions governing the test cannot be kept as uniform as in a laboratory. It should be noted that the lubricant that is best for one alloy is not necessarily so for any other. In fact, too much importance should not be given to the alloy of the bearing metal. In some cases, and especially in railway practice, the alloy that gives the least wear may, for other reasons, be the one that should not be used. The authors' statement that "the alloy which can endure the greatest amount of distortion without rupture will give the best results in wear" is a natural deduction from Tower's experiments, but depends upon distortion, due to a poor distribution of the load, for its conclusion. It sometimes occurs that the use of a bearing metal that will wear more rapidly is the cheaper solution of the problem. Perfect distribution of load and alinement permit perfect lubrication and, consequently, the use of hard metals with a minimum of frictional resistance and wear.

The same remarks apply to Job's statement.* The reasons he gives for heated railway journals are the last that should be sought. There are so many other causes that are much more flagrant. The problem would be much simpler of solution than most roads have found it if the causes were as stated by Mr. Job.

For further information relative to alloys, reference may be had to the tests made by the U. S. Government. The results obtained by the U. S. Ordnance Department with yellow brass (see its specifications) do not confirm those stated by the authors.

The reviewer does not think sufficient emphasis has been placed, in Chapter X., upon the relation between the distribution of the load and the maintenance of good alinement on the successful lubrication of bearing surfaces. If these are well taken care of and suitable oil for the pressure and speed is selected, ideal practical results may be expected.

The descriptions of various forms of bearings and lubricators in Chapter X. are more historical than complete. No mention is made of the method of lubricating from a central point and the return of the lubricant thereto. With sight-feed lubricators and the use of a cylinder oil of proper body, and with balanced valves, the re-

*Consulting Engineer, 30 Pine St., New York.
*Proc. Inst. M. E., 1883, 1885, 1888 and 1891.
†Trans. Amer. Society Mech. Engrs., Vol. I.

*Jour. Franklin Inst., 1903.
†Ditto, 1892.

*Jour. Franklin Inst., 1900.

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viewer would accept, after some modifications, the conclusions of the authors relative to efficient cylinder and valve lubrication.

Chapter XI., "The Lubrication of Machinery," is more extended than seems necessary.

The book is a valuable addition to the literature for physical and chemical laboratory use. A large part of it, however, applies more to English than American practice.

If the users of lubricants can be led up to the conclusions reached by Tower, much good will have been accomplished. Present-day practice is far from being in accordance with those conclusions, but existing conditions must and will change as their importance becomes appreciated.

Mathematics in Small Compass.

A COURSE IN MATHEMATICS.—For Students of Engineering and Applied Science. By Frederick S. Woods and Frederick H. Bailey, Professors of Mathematics in the Massachusetts Institute of Technology. Vol. I. Algebraic Equations, Functions of One Variable, Analytic Geometry, Differential Calculus. Boston and New York: Ginn & Co. Cloth; 5½ × 8½ ins.; pp. 385; 219 illustrations in the text. $2.25; by mail, $2.40.

MATHEMATICAL HANDBOOK.—Containing the Chief Formulas of Algebra, Trigonometry, Circular and Hyperbolic Functions, Differential and Integral Calculus, and Analytical Geometry, together with Mathematical Tables. Selected and Arranged by Edwin P. Seaver, A. M., LL. B., formerly Assistant Professor of Mathematics in Harvard University. New York: McGraw Publishing Co. Cloth; 5 × 8½ ins.; pp. 279. $2.50.

An entire rearrangement of the mathematical studies comprised in engineering college courses, as embodied in Woods & Bailey's work, should engage the attention of all who are concerned with the administration of such courses. The objections which may readily be urged against it are counterweighted by some positive merits. The essential unity of algebra, analytic geometry and calculus is not clearly impressed on the student's mind in the usual separated teaching of these subjects. Instead, he is made aware most strongly of their radical differences of method. By amalgamating the subjects in a single consecutive development it is possible to secure far more thorough understanding, on the part of the student, of the nature and interrelation of the various operations discussed. This, we take it, is the fundamental purpose in the work whose first volume is before us. It has been carried through with almost as much appreciation as the language are clear and logical; reinforced by an abundance of illustrative problems so selected as to keep to the front the unity of the entire subject, the text seems to possess adequate vitality for good service in either class-room or independent study. It will be questioned, of course, whether the principles of each separate branch of the subjects included will be so thoroughly absorbed by the student as in the separate course system. This question, having primary application to the calculus, can not be answered from the present volume because the main treatment of calculus is reserved for the succeeding volume. Only a preliminary opinion of the work can be formed in the meantime, therefore. Irrespective of this, however, the authors' work is highly creditable, and the work can be recommended as being freer of obscurity and therefore better for self-study than many recognized text-books of mathematics.

A quite different book, of very much wider appeal, is Seaver's "Mathematical Handbook." This is a true handbook, in the sense that it is a compendium of *results* only. Covering the fields of algebra, geometry and trigonometry (plane and spherical), hyperbolic functions, calculus and analytic geometry, it may be likened to a collection of text-books on these subjects with all demonstrations and intermediate steps omitted, thus leaving only the final formulas of each operation. This general scheme has been carried out by the author in admirable fullness. He has included many matters not found in ordinary text-books, and thus furnishes the tools for handling not only the more common, but also the special mathematical problems that occasionally come before the engineer.

But a further feature of the book that will meet with almost as much appreciation as the text-matter itself, is an excellent collection of tables. These are as follows: (1) Squares, cubes, square and cube roots, cube roots of squares, and reciprocals, of numbers from 1 to 1,000; (2) five-place common logarithms of numbers from 1 to 10,000; (3) binomial coefficients and factorial products, both up to 20; (4) natural or hyperbolic logarithms of members to 1,000; (5) three-place trigonometric functions by degrees; (6, 7, and 8) five-place trigonometric functions by 10 mins.; (9) five-place logarithms of trigonometric functions by 10 mins.; (10) four-place values of circular and solid angle, for degree arguments; (11) circumferences and areas of circles and volumes of spheres for diameters up to 200; (12) dimensions of circular segments for central angles up to 180°, by degrees; (13, 14, 15) natural values and common logarithms of hyperbolic sine, cosine and tangent, from 0 to 5.09 for the two former and from 0 to 2.39 for the hyperbolic tangent, varying by hundredths; and tables of mathematical constants, tables of weights and measures, and a table of $\sqrt{2gh}$ for various values of h.

Prof. Seaver's book is to be recommended highly, as a very necessary reference manual. Being a first edition, it may possibly prove to need expansion in this or that point, as the stress of practical use reveals weak spots. But in the main it is successful, both in the general plan and in its execution. As to the unavoidable typographical errors, we would urge, since a book of this kind depends vitally on typographical accuracy, that errors detected by users of the book be reported promptly to the author.

A Useful Tree Book.

HANDBOOK OF THE TREES OF THE NORTHERN STATES AND CANADA.—East of the Rocky Mountains. Photo-Descriptive. By Romeyn Beck Hough, B. A., Author of "American Woods." Lowville, N. Y.: The Author. Cloth; 6¾ × 9½ ins.; pp. 470; 498 illustrations in the text. $8.

Each tree taken up by the author in this work is given two pages. On the left-hand page appear the common name or names and the scientific name of the tree, as a title to a half-tone illustration showing a branchlet of the tree with leaves and mature fruit, and also showing a winter branchlet to exhibit the winter buds. Sometimes the fruits are also shown detached from their supporting branchlets. All these parts of the tree are photographed attached to paper ruled into 1-in. squares, thus affording a scale. A portion of the opposite page contains a half-tone view of the lower part of the trunk of the tree, to exhibit the characteristics of its bark and such other features as can be included. A foot-rule fastened to the tree supplies a scale. In many instances a photo-micrograph (× 15) illustrates the structure of the wood, as shown in transverse section. The half-tones of the tree trunks, either with or without the photo-micrographs, occupy the right-hand half of the page; the other half is devoted to text, except for a small map at the bottom of the column, showing by shaded areas the distribution of the tree in question throughout the several states.

The brief text given for each tree sets forth its general characteristics, geographical, topographical and soil distribution, the main characteristics of the wood, and the principal uses of the latter. The weight of a cubic foot of the wood, seasoned, is also given. Following the general and more popular information just outlined, there is for each tree, in smaller, unleaded type, a botanical description of its leaves, flowers and fruit. Finally, reference is made to the proper page number, in the back part of the book, for information regarding the families and genera of the several trees.

Both native and naturalized trees are included. The region covered includes the area "north of the northern boundaries of North Carolina, Tennessee, Arkansas and Oklahoma, and east of the Rocky Mountains, and extending southward in the Appalachian region to Northern Alabama and Georgia. It may be inferred from the preface that all the photographic material used in preparing the book, with possibly a few exceptions, was collected by the author and that the photographs were made by him. The book appears to us to be one of the most satisfactory of its kind yet published. A book like this one, in some respects, but containing more information of particular value for engineers, is "The Principal Species of Wood," by Prof. Charles H. Snow, M. Am. Soc. C. E., of New York University (see this Supplement for May 14, 1903). Besides giving the weight of the seasoned wood, as does the present author, and its representative uses, Professor Snow also gives its modulus of elasticity and rupture. The characteristics of leaves, flowers and fruit, in Professor Snow's book, are shown by wash drawings, and for this reason, and because of lack of scale, they are not as satisfactory as those in the present volume. Of course, it should be understood that Professor Snow's book dealt with, to quote from our review, "each species that is of any importance in construction,

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Ten thousand contractors and engineers have bought one book, and a very great percentage have subscribed for the paper edited by the author of that book. We refer to Gillette's "Handbook of Cost Data," and to "Engineering-Contracting," the latter being a weekly periodical for civil engineers and contractors. The "Handbook of Cost Data" has broken all records for the sale of an engineering book, because it is full of detailed costs of all kinds of actual construction. The handbook contains 622 pages, bound in leather, and its price is $4 net, postpaid. "Engineering-Contracting" is $2 a year (52 copies), but for a short time $1 will be accepted for a full year's subscription.

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decoration and furniture, in manufacture of implements and materials, or for its by-products," whereas Mr. Hough's book deals with the species, both native and naturalized, found in a delimited but extensive section of the country.

The material for illustrations in the present volume is remarkably well chosen and presented. The general descriptions seem to be satisfactory. We do not presume to pass judgment upon the technical descriptions of leaves, fruits and flowers, but see no reason why they are not both correct and well suited to the purposes of such a volume.

Gas Work Chemistry.

Reviewed by ALFRED E. FORSTALL.*

THE CHEMISTRY OF GAS MANUFACTURE.—A Practical Manual for the Use of Gas Engineers, Gas Managers and Students. By Harold M. Royle, F. C. S., Chief Chemical Assistant at the Beckton Gas Works. New York: The Norman W. Henley Publishing Co. London, England: Crosby Lockwood & Son. Cloth; 5½ × 8¾ ins.; pp. 328; 1 plate and 82 text illustrations. $4.50.

In the preface the author states that in this book he

> has endeavored to furnish the working gas engineer and manager with a concise manual, covering questions and points requiring attention in the ordinary course of his duties.

If the ordinary course of duty of the working gas engineer in charge of one of the smaller gas plants in Great Britain requires him to do all of the chemical work covered in the pages of this volume, his ideas, or possibly those of his employers, as to how his time may be most profitably employed differ very widely from those held in the United States. The writer does not care to express an opinion as to which set of ideas is to be preferred. Under the conditions, however, the American gas engineer has no great need of such a manual, and yet it would be advisable for him to purchase this book to see what his fellow-workers in Great Britain consider to be part of their routine work.

Starting with the method of preparation of the standard solutions required in the chemical work which it seems to be customary to carry on in an English gas plant, the body of the book goes on through coal testing, flue-gas analysis, the distillation of coal and coal tar, the analysis of crude coal gas, and those of purifying materials, ammonia, fire clay and fire brick, the testing for naphthalene in gas and a short description of the various methods employed for preventing its deposition in the distribution system, and the determination of the candle power, the calorific value and specific gravity of illuminating gas, and is concluded by a short chapter on the testing of the oil used and the oil tar produced in the manufacture of carburetted water gas.

Three appendices, covering 68 of the 316 pages of the text, contain the "Notifications of the (London) Gas Referees for the year 1907" in full, a few abstracts of articles from various chemical and gas periodicals, bearing upon the subject of the book, and the tabular matter that one has come to expect to find given in every book of this kind.

The tests and the methods of analysis given in the book cover very fully those required in the operation of gas works, including many seldom, if ever, made in the United States. But it is to be noted that when dealing with the question of the removal of naphthalene from coal gas, or failing this, the prevention of its deposition in a solid form in the distributing system, the author, while giving a resumé of the most important work done along these lines in Great Britain, does not mention work equally important that has been carried on in connection with the scholarship in the University of Michigan, maintained by the Michigan Gas Association, although this work has been fully reported and the reports have been published in the English gas journals. In the chapter on photometry and gas testing the descriptions of the photometrical equipment required are very brief, and the treatment of the manner in which the candles used in making photometrical tests should be handled in order that they may give the proper amount of light is very inadequate, and not entirely accurate.

*Consulting Engineer, 58 William St., New York City.

The tests and methods of analysis described in the book are not claimed as original, but are compiled partly from matter to be found only in various periodicals, and partly from other English books dealing with the work of the chemist of a gas company. The condensation of the matter taken from periodicals is not always accurately done. This lack of accuracy seems to be largely due to inability on the part of the author always to express clearly just what he wishes to say, as is strikingly shown in the description given of some experiments made by himself to determine the degree of hydration of the ferric oxide contained in the natural bog ore so largely used in Great Britain for the removal of sulphuretted hydrogen from illuminating gas, given on pages 149 and 150. The writer of this review has read these pages over several times, but does not yet know exactly what the experiments proved, or even what the author thought they proved.

Another fault of the book is found in typographical errors, which are the more important because several of them occur in the spelling of proper names. An example of these errors is found in a reference to an article by Dr. J. Grossman in which the name is given as Crossman, and in the chemical equations quoted the multiplication sign is used instead of the letter x, while the figure 4 takes the place of the letter y.

There are also faults of arrangement. Logically all the matter connected with purifying materials should be grouped together, but almost half of this matter, that dealing with the analysis of Weldon mud and the analysis of spent oxide, is put in as part of the chapter on the analysis of fire clay, and there are several instances of definitions placed where one is surprised to find them.

The faults mentioned do not, however, detract materially from the value of the matter contained in the book, and, as previously stated, it is worthy a place in the libraries of American gas engineers.

ELECTRO-ANALYSIS.—By Edgar F. Smith, Professor of Chemistry, University of Pennsylvania. Fourth Edition, revised and enlarged. Philadelphia, Pa.: P. Blakiston's Son & Co. Flexible leather; 5 × 7½ ins.; pp. 336; 42 illustrations in the text. $2.50, net.

The advances in methods of electro-analysis made by the author of this book, and by students under his direction at the University of Pennsylvania, have become generally known to all persons interested in electrolytic processes. But there has been no very complete collection of the information and data which have become available and the introduction of such matter into a new edition of an older text seems most opportune. These new methods involve, for the most part, the use of a rotating anode and a mercury cathode to assist a rapid precipitation of metals. As a knowledge of the older processes, without rotating anodes and mercury cathodes, is very necessary in training chemists and electro-chemists, the author has, in introducing the new methods, kept most of the former ones also. The work outlined for the various determinations is therefore arranged in progressive order: first is given the older and slower process, with stationary electrodes; then follows the method using the rotating anode, and finally the use of a rotating anode and a mercury cathode is outlined. The economy in time, the neatness, the accuracy and the simplicity of the newer operations are very evident to one who reads this text-book.

The book begins with a few broad and general ideas of electrolysis. The equipment of the excellent special laboratory at the University of Pennsylvania is briefly sketched. In some forty pages succeeding there is given, in carefully condensed form, a great mass of theoretical and historical considerations of electro-analysis, of the rapid precipitation of metals and of the use of mercury cathodes. The greater part of the book is given up to actual methods in the determinations of the different metals, in the separations of the metals and in the determinations of the halogens, of nitric acid and of anions and cathions. In the treatment of these methods actual lines of procedure are clearly and concisely set forth, as they have been found successful in actual laboratory practice. In many cases the conditions conducive to failure are outlined as well. As mentiond before, the metallic determinations and separations are given first for the use of stationary electrodes, secondly for the use of revolving anodes and finally with the mercury cathode.

Throughout, the references to original sources of information and to collateral reading seem very complete, permitting the fullest extension of study on even small subdivisions of the work outlined in the text. The paragraphing with captions and side heads in heavy type facilitates rapid use of the book.

REPORT ON RAILWAY SURVEYS: CAPE GOVERNMENT RAILWAYS.—Pub. Doc.. Railway Department, Cape Town, Cape Colony, South Africa. Paper; 8 × 12¾ ins.; pp. 14; two folding maps.

This contains the reports of engineers on the surveys of some railway extensions. The estimate for one of these is $18,655 per mile, or $20,535 including rolling stock. It is interesting to note that on an 80-mile line nearly all the streams were found to be salt, so that the water stations had to be included. Each of these will have wells, pumps and an excavated reservoir.

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Plane Surveying.

PLANE SURVEYING.—A Text-Book and Pocket Manual. By John Clayton Tracy, Assistant Professor of Structural Engineering, Sheffield Scientific School of Yale University. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Leather; 4 × 7¼ ins.; pp. 794; 604 text illustrations, 1 folding plate and 18 tables. $3; English price, 12s. 6d., net.

SURVEYING.—A Manual of Practical Instruction in the Art of Plan Surveying, Including Plotting, Leveling, Triangulation, Line Running, Cross-Sectioning, Traversing, and Other Details of Field Work. By Alfred E. Phillips, Ph. D., Professor of Civil Engineering, Armour Institute of Technology. Chicago, Ill.: American School of Correspondence. Cloth; 6½ × 9¾ ins.; pp. 207; plates and text illustrations. $1.50.

The utility of an additional work on plane surveying is certainly open to question. In spite of the publication of numerous treatises from the pens of nearly every professor of surveying in the larger scientific schools of this country, it is probable that most of the courses in surveying, outside of those in charge of the authors of the above-mentioned books, are conducted under the instruction of the standard works by Johnson and Raymond, after which the greater portion of the later text-books are modeled. This very similarity in method of treatment is undoubtedly the reason why the old standards are still so popular. No new text-book can gain wide usage unless marked superiority in method and treatment can be shown, for a teaching staff is loath to subject its whole system of instruction to a change which is always made necessary by the adoption of another book, unless some other advantage than mere details of arrangement or amplified explanations can be shown.

A book on plane surveying is intended primarily for the student—both in initiative instruction and as an aid in field study—and secondarily as a handbook for practicing surveyors. By far the most important of these two is the former, for the average practicing surveyor has but little use for anything except mathematical tables; the principles of his profession should be a part of his knowledge. However, most of our existing treatises on the subject disregard the fields they should cover except that of instructing the student in the theories and practices of surveying to be learned from the book in the class-room and supplemented by oral instruction in the field-work which, in many of our schools, comes after the entire academic discussion of the work has been finished. Gradually the idea has been developed that it is necessary to carry on class-room instruction with field-work in order to convey to the student a proper appreciation of the difficulties and conditions of actual practice. In the application of this idea the old text-books have been found at fault and a large amount of supplementary oral instruction has devolved upon the teaching force.

To supplement the text-book and, in a way, to save the instructor much unnecessary labor, several small handbooks have been published treating solely the field practice of surveying, and intended to be used only as aids in understanding the more theoretical principles advanced by the larger books. Prof. Tracy's book goes a step further and includes in one volume the theoretical and the practical. In shape, size and make-up it closely resembles the better-known handbooks by Trautwine and Kent and is therefore equally handy in field or study. In arrangement it is expressly suited to the needs of the student. Particularly is this noted in the method of treatment. Instead of starting with a lengthy description of instruments, their design, construction and adjustment, the first few chapters treat directly of the methods of field work. Passing through field-work with many examples of actual practice, the subject of office work is next taken up and then a description of the instruments used in the work is placed near the end, where reference to it can be made at any time. Enough information about each instrument is given in the chapters on field-work to enable the student to understand its proper use, but the careful and intricate descriptions are left to the final chapter. Particularly to be noted in the book are the extensive explanation of field notes, the instruction on the importance of the theory of error, and the attention paid to many minor matters of field method. One especially good point is that the general treatment of traverse surveying is taken up first with the transit and not with the obsolete compass as has before been the practice. Prof. Tracy has written a book of great value to the surveyor, both in his student days and in the first years of his practice, before he has had time to fully compile his experience. The only objection to the book which might be made is that it is so large and complete that considerable familiarity with its contents will be necessary before it can reach its highest value.

The second book noted in the headpiece is an example of one of the older class of books noted above. While it has little to distinguish it from any one of many similar works, yet it seems to be well adapted to the purposes of a correspondence school.

THE UTILIZATION OF WOOD WASTE BY DISTILLATION.—A General Consideration of the Industry of Wood Distilling, Including a Description of the Apparatus Used and the Principles Involved, also Methods of Chemical Control and Disposal of the Products. By Walter B. Harper, M. S. St. Louis, Mo.: Journal of Commerce Co. (St. Louis Lumberman). Cloth: 8¾ × 11¾ ins.; pp. 156; 74 illustrations in the text. $3.

Compared with operations abroad, scarcely anything has yet been done in the United States to utilize the wood wastes incidental to lumbering and other forest cuttings. The rapid depletion of the timber resources of the country makes it highly desirable that utilization methods be adopted as rapidly as possible, to the end that every portion of every tree that is felled shall be put to some useful purpose—unless, indeed, the recovery of by-products cost more than they are worth.

The object of the present volume is to make good to some extent "the lack of literature on the subject of wood distillation, particularly that which relates to the treatment of resinous woods." The chief wood considered is the long-leaf yellow or Georgia pine. This of course limits the usefulness of the book, but such a limitation has its advantages. In carrying out the plan of the author, however, much information is given that is quite as applicable to any of the other woods as to yellow pine.

After a brief historical outline of the destructive distillation of wood, the author describes in succession the various ovens and other apparatus necessary for destructive distillation, refining methods, and combinations of distilling and refining apparatus. These and other chapters appear to include descriptions of the chief patented processes that have been brought out in this country. A brief but practical chapter is entitled "General Consideration for the Establishment of a Plant." This chapter takes up market conditions, and also the necessary steam plant. Another chapter discusses in detail the "composition of wood and products of distillation," the latter including among other things tar, wood vinegar and wood alcohol, turpentine, pine and resin oils, resin, pyroligneous acid, and charcoal. There is a brief chapter on the yields and disposals of products, another on chemical tests, and a final one on the chemical control of distilling plants. A brief "Bibliography" concludes the volume, but unfortunately this, for the most part, consists of titles, only, without dates, publishers, etc.

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Author and Publisher

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Price of Book, $2.50 To Clubs of 5, $2.00

SWITCHES AND TURNOUTS.—Howard Chapin Ives. (Reprinted from the "Journal of the Worcester Polytechnic Institute" for March, May and July, 1907.) Worcester, Mass.: The Institute (J. D. Williams, Sales Agent). Paper; 6¼ × 8¾ ins.; pp. 13 + 10 + 7; illustrated. 50 cts.

This little book, a reprint of three consecutive papers in the Journal of the Worcester Polytechnic Institute, is a mathematical discussion of the general scheme of computing and laying out switches and turnouts. The first paper treats of these connections on a tangent, the second on a curve and the third of the general field methods of laying out on the ground.. While not developing any new theory, the arrangement of the material is good and the mathematical treatment concise, so that it forms a handy reference book to add to the railway engineer's hand book.

TEXT-BOOK OF MECHANICS.—By Louis A. Martin, Jr., Assistant Professor of Mathematics and Mechanics in Stevens Institute of Technology. Vol. II., Kinematics and Kinetics. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4¾ × 7½ ins.; pp. 214; 91 illustrations in the text. $1.50, net.

The fundamental principles of elementary Mechanics are presented in simple manner and in logical order in this volume. The kinematics and kinetics of the heavy particle and of the solid body are treated in about the same degree of detail as usually included in courses of Mechanics for engineering students. There is an abundance of exercises and problems.

TUBERCULATION AND THE FLOW OF WATER IN PIPES.—By Nicholas S. Hill, Jr., C. E. A Paper Presented at the 27th Annual Convention of the American Water-Works Association. (J. M. Diven, Secy., 14 George St., Charleston, S. C.) Paper; 6 × 9¼ ins.; pp. 303 to 374; text illustrations and one folding diagram.

There is here brought together a large amount of interesting and valuable information on the important subject of tuberculation of water

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mains and the flow of water in pipes. A study is made of the causes of tuberculation, and also of its effects in relation to carrying capacity. The author states that his work has been chiefly that of a compiler, but it may be noted that in this case it is none the less valuable on that account.

A Correspondence-School Cyclopedia.

CYCLOPEDIA OF ARCHITECTURE, CARPENTRY AND BUILDING.—A General Reference Work on Architecture, Carpentry, Building, Superintendence, Contracts, Specifications, Building Law, Stair-Building, Estimating, Masonry, Reinforced Concrete, Steel Construction, Architectural Drawing, Sheet Metal Work, Heating, Ventilating, etc. Prepared by a Staff of Architects, Builders and Experts. In Ten Volumes. Chicago, Ill.: American School of Correspondence. Cloth; 6½ × 9¾ ins.; pp. (total) 3913; numerous plates and text illustrations. Introductory price, $19.80; list price, $60.

In the consideration of so ambitious a work as this cyclopedia the purpose which it is intended to serve should control any estimate of its value. A cyclopedia is a compendium of all available or at least desirable knowledge of one branch of science, art or learning. Its utility is measured by the completeness of its treatment and by the compactness of its arrangement; not by its infinite detail or minute analysis. It should contain all things fairly well treated rather than a few completely studied. It can never replace the text-book; its place on the library shelves is that of the bureau of information, and ready reference for the solution of the casual problem upon which more exhaustive research is superfluous. Ostensibly, the Cyclopedia of Architecture, Carpentry and Building fulfills all these obligations. In reality there are certain not altogether apparent limitations in its scope which must measureably affect any judgment passed upon it. These limitations are largely a result of the scholastic nature of the publishers of the work and of their avowed intention to make the various volumes, if not directly applicable to, at least useful for home study, as is instanced by the following phrase from the preface:—"The Cyclopedia is a compilation of many of the most valuable Instruction Papers of the American School of Correspondence." The position of the correspondence school in the educational world is one of proved value. By its peculiar methods of instruction it reaches a class of men, needful of education and profiting greatly by it, who from lack of means or opportunity have not been able to avail themselves of any higher learning. However, any of the publications of such a school can never be anything but text-books, and at that, text-books of a more or less elementary nature from which the more complicated and involved discussions must be removed.

Bearing in mind, then, the restrictions imposed by the intended use of the original papers, the compilation has resulted very favorably. The staff of experts who are responsible for the various portions are all men noted in their particular line and fully capable of giving valuable instruction. The subjects embraced are extensive enough to cover the broadest definition of a cyclopedia. The illustrations are well selected. Although most of the sketches and diagrams have a familiar appearance, yet they help out the text to the required extent. Taken as a whole, the work is an admirable example of a universal compendium of knowledge for the busy man who has not the time or the ability to gather his information first hand from more authoritative and scientific sources. It in no sense can be considered of great value to the informed engineer or architect who has kept up with his profession.

The cyclopedia consists of ten octavo volumes, each of some three hundred odd pages; two sets of page numbering indicating the original separated manner of publishing. The titles of the several volumes are as follows: (1) Building Superintendence, Contracts and Specifications, Building Law; (2) Carpentry, Stair Building, Estimating, the Steel Square; (3) Strength of Materials, Statics, Masonry Construction, Hardware; (4) Reinforced Concrete, Steam and Water Fitting, Electric Wiring, Electric Lighting; (5) Steel Construction, Elevators; (6) Architectural Drawing, Lettering; (7) Freehand Drawing, Perspective; (8) The Architectural Orders, Pen and Ink Rendering; (9) Plastering, Painting, Sheet Metal; (10) Heating, Ventilating, Plumbing. Throughout the work there are placed drawings and half-tones of many examples of ancient and modern architecture, principally of residences of moderate cost, through observation of which the reader may have impressed upon him, perhaps unconsciously, an appreciable knowledge of what is good and true in architectural design.

Four Pocket-Size British Books.

HOW TO USE WATER POWER.—By Herbert Chatley, B. Sc. (Engineering), Lecturer in Civil Engineering and Applied Mechanics, Portsmouth; Author of "How to Make a Survey," etc. London, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4¾ × 7¼ ins.; pp. 92; 23 illustrations, mostly in the text. $1, net.

MODERN STEAM TRAPS.—(English and American): Their Construction and Working. By Gordon Stewart. London, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4¾ × 7¼ ins.; pp. 104; 71 illustrations in the text. 3s., net; American price, $1.25, net.

NOTES ON THE CONSTRUCTION AND WORKING OF PUMPS.—By Edward C. R. Marks, M. Inst. M. E., Assoc. M. Inst. C. E., Author of "Notes on the Construction of Cranes and Lifting Machinery," etc. Second and enlarged edition. London, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4¾ × 7¼ ins.; pp. 259; 159 illustrations in the text. 4s. 6d., net; American price, $1.50, net.

THE "MECHANICAL WORLD" POCKET DIARY AND YEAR BOOK FOR 1908.—Containing a Collection of Useful Engineering Notes, Rules, Tables and Data. Manchester, England: Emmott & Co., Ltd. Cloth; 4 × 6¼ ins.; pp. 391; 59 illustrations in the text. 6d., net; American price, 20 cts.

Mr. Chatley's general method of treatment is indicated by a few sentences from his preface:

> This little book has been designed to meet a felt want. The subjects referred to are of increasing importance; but the study of it is almost prohibited to those who cannot spare the time to study applied mechanics in the lump. There are many excellent works, but the majority are too mathematical for the young engineer to tackle at first.

The author has endeavored to cover (with the full number of loose ideas that might be expected after reading the above statements) a wide variety of subjects; sources of water power, transmission, water-wheels, turbines and other hydraulic machinery, dams, tidal power, water supply and sewage disposal. The author may have correctly judged the demands abroad for an elementary and almost popular treatment of these subjects, but he seems to have failed to produce a book to satisfy the expected demands.

"Modern Steam Traps" consists of a collection of papers which have appeared in an English trade paper. The general need for separators and traps in piping systems is outlined and the general requisites of a trap are mentioned. The major part of the work is devoted to descriptions of a large number of English and American steam traps and their methods of operation. These are segregated under the heads of expansion, float-operated, bucket, thermostatic and differential water-pressure types. The illustrations are, for the most part, of the familiar catalog variety.

Since the first edition of "Notes on Construction and Working of Pumps," was published, in 1902, the use of centrifugal pumps has been extended to high-lifts not considered possible at that time. On this account some new matter is introduced on this apparatus. Several chapters deal with conditions affecting all types and makes of pumps. Among subjects treated are: limit of suction lifts; piston speeds; the design of air vessels, pipes, connections, valves and packings. The better known makes of American and English pumps, of all kinds, are described in catalog style, with catalog illustrations. For such description these makes of pumps are grouped into several classes, such as boiler-feed, mine, hydraulic pressure, Savery type, power, electric, centrifugal and rotary, manual and animal-power, rams, large capacity and high-duty pumping engines. With each description is given considerable operating data. There is an appendix of patents relating to centrifugal and turbine pumps.

The annual pocket-book named at the head of these notes contains the usual data on weights and measures, physical properties, conversion factors, tables of squares, cubes, fourth powers, logarithms, etc. Much space is devoted to data and formulas for the design of parts of steam engines and boilers. Some general information is included on gas producers, gas engines, oil engines, beams and girders.

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The book is so complete that it can be put in the hands of a young engineer with confidence that it will enable him to make reliable tests on cement. The wealth of photographs and line cuts furnish the pictorial examples of how to conduct cement tests, and the 300 pages of texts are so explicit that even the most inexperienced man can soon learn the art of cement testing. Yet the book has not a superfluous paragraph. The list of chapters includes: (1) Classification and Statistics, (2) Composition and Constitution, (3) Manufacture, (4) Inspection and Sampling, (5) The Testing of Cement, (6) Specific Gravity, (7) Fineness, (8) Time of Setting, (9) Tensile Strength, (10) Soundness, (11) Chemical Analysis, (12) Special Tests, (13) Approximate Tests, (14) Practical Operation, (15) Other Varieties of Cement than Portland, (16) Specifications (The Author's, Am. Soc. C. E.; Am. Soc. Test. Mtls.; Soc. Chem. Indust.; Corps Engrs. U. S. A.; British Standard, Can. Soc. C. E.).

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Two Reliable Guides to Safe Investments.

POOR'S MANUAL OF THE RAILROADS OF THE UNITED STATES.—Street Railway and Traction Companies, Industrial and Other Corporations. 40th Annual Number, 1907. New York: Poor's Railroad Manual Co. London, England: Effingham Wilson. Cloth; 6 × 9 ins.; pp. 108 + xvi. + 1,774; folding and other plates. $10.

AMERICAN RAILWAYS AS INVESTMENTS.—A Detailed and Comparative Analysis of All the Leading Railways, from the Investor's Point of View; With an Introductory Chapter on The Methods of Estimating Railway Values. By Carl Snyder. New York: The Moody Corporation. London, England: Frederic C. Mathieson & Sons. Cloth; 6¼ × 9½ ins.; pp. 762; one folding map. $3.20, net; by mail, $3.40.

All financiers agree that the closing months of 1907 have offered greater opportunities to investors than have been known in many years. Stocks and bonds of sound corporations have been offered in the market at a price representing larger dividend and interest returns on the selling price than have been available to investors in a long time. Many millions of dollars have been spent during the past two months in the purchase of small lots of stocks, by people who lay them away and remove them from the speculative maelstrom of Wall Street. Doubtless many millions more will be similarly invested during the next few months. Every such investor has to choose the property in which he will invest his money, and if he is wise he will seek some fuller source of information than daily market reports or brokers' circulars.

For the man who places his money in railway securities, for investment and not for speculation merely, the two books before us offer better and more reliable aid than he can obtain, as a rule, even from well-posted bankers or brokers. The first of these, "Poor's Manual," is too well known to need more than reference here. Its figures are compiled from official sources, and the same information is given in compact compass arranged for ready reference, that one could only obtain otherwise by hunting through the reports to stockholders made by a thousand different railway companies.

In Poor's Manual, however, no deductions are made. The bare figures are presented and the reader is left to make his own interpretations and conclusions. Realizing the difficulty experienced by the average investor in interpreting railway reports of earnings and expenses, Mr. Snyder has prepared a treatise designed to enable a layman to form a much more accurate idea of the safety of an investment than he can possibly do even from a railway's official reports. The book covers some 200,000 miles of railway, or 90% of the total mileage of the United States and Canada.

In his Introduction the author says:

> In this book, I wish to provide a work whereby the investor, instructed or not, may look at the market quotations of a given stock, and, within broad limits, determine for himself whether this stock is cheap or dear, whether it be a good time to buy, or if he holds stocks to sell.

In his discussion of the various railways, the author introduces the term "Factor of Safety" with reference to bond issues and "Margin of Safety" with reference to preferred stock payments. These terms show in plain figures what the investor may rely upon in the way of margin to secure the continued payment of his interest or dividends. Of course these figures must be considered over a series of years and not for a single year of phenomenal earnings or extraordinary losses, in order to secure a fair idea of the real situation.

When one considers the limited knowledge with which most investments are made in stock market securities, it would seem that Mr. Snyder's book ought to have a very wide circulation.

HIGHWAY CONSTRUCTION.—A Practical Guide to Modern Methods of Roadbuilding and the Development of Better Ways of Communication. By Austin T. Byrne, Author of "Highway Construction," "Materials and Workmanship," and Alfred E. Phillips, Ph. D., Professor of Civil Engineering, Armour Institute of Technology. Chicago, Ill.: American School of Correspondence. Cloth; 6½ × 9¾ ins.; pp. 136; 79 illustrations in the text and 2 plates. $1.

For those desiring an epitome, somewhat popularized, of Prof. Byrne's cyclopedic volume on the same subject, the book before us will doubtless serve admirably. The larger volume was reviewed at length in our issue of Aug. 15, 1907. It seems a pity that commercial considerations seem to exclude, in the correspondence school publications, reference to other and more extended works on subjects treated. So far as we have found, the text of the present volume conveys no idea of the fact that those designing more detailed information can find it in Prof. Byrne's larger book. The title page does state that Prof. Byrne is author of a book on "Highway Construction," a statement that is unnecessarily confusing in view of the abbreviation of the real title—"A Treatise on Highway Construction"—so that the title as quoted is identical with the main title to the volume before us.

Track Deformation.

DEFORMATIONS OF RAILROAD TRACKS.—And the Means for Remedying Them. By G. Cuënot, Chief Engineer of Bridges and Highways Attached to the Board of Control of the Paris-Lyons-Mediterranean R. R. Co. Authorized Translation by W. C. Cushing, Chief Engineer of Maintenance of Way, Pennsylvania Lines West, Southwest System. New York: The Railroad Gazette. London, England: The Railway Gazette. Cloth; 5¾ × 9 ins.; pp. 147; 35 illustrations in the text. $2.

In view of the great importance of railway track to modern transportation and to the safety and efficiency of the transportation service, it is curious that so little attention has been given to it in the way of scientific investigation. Its various component parts have been studied and we have numerous investigations as to rails, ties, joints, the holding power of spikes, etc. But the investigation of the track as a complete structure and of its behavior under the conditions of carrying traffic has been almost neglected. Mr. Cuënot, the author of the book before us, says in his preface that the increase in speeds of traffic makes necessary a minute study of the track, to ascertain the forces to which it is subject, and to determine how it may be made stronger. He first deals with the object and nature of the experiments, which originated with tests of some composite ties, by direction of the Minister of Public Works. Then followed the study of the principal movements of the track structure (both longitudinal and transverse) which cause its deformation. Reference is made to earlier experiments by Mr. Couard (in France) and Mr. Ast (in Austria), the former using special instruments and the latter employing instantaneous photography. German experimenters are also noted. Special apparatus has been designed by Mr. Ferry, Sub-Engineer, for the work on the Paris, Lyons & Mediterranean Ry., to show the movements of ties under load, and several pages of diagrams show the results obtained under various conditions. The investigations have included both static and dynamic tests, and considerable space is devoted to a discussion of the length of ties. The longitudinal movement or "creeping" of track, as well as the effect of widening gage on curves, joints and fastenings, are discussed, and there are drawings of interesting machines devised by another engineer, Mr. Collet, to record the vertical force exerted upon the screw spikes, and the lateral forces tending to spread and lift them. The influence of tie-plates upon the resistance to lateral forces is also shown.

The various matters are discussed scientifically and in detail, and the closing chapter discusses methods for remedying track deformations. The first point is the bearing of the tie upon the ballast and the arrangement of the tamped bearing surfaces, and it is not difficult to see why deformation of track is such a serious trouble in this country, when track tamping is not done by skilled laborers permanently employed, but by the poorest grades of common labor, whose efforts are governed by "sheer strength and awkwardness." One conclusion reached is that the zone of influence of the load is very limited, extending only about 13¾ or 15¾ ins. from the point of application (the center of the rail). The author concludes that the following points are necessary for a track to carry a heavy and rapid traffic: (1) Ties two or three times more rigid than those now in use (which excludes the use of steel ties of trough section); (2) the use of the three-tie type of rail joint, with ties 12 ins. apart; and (3) the use of reinforced tie-plates (that is, having

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ribs to support the back part of the head of the screw spike).

The mechanical work on the book is rather poor, the printing being dirty in places, and several of the diagrams being very black. The translation is also somewhat awkard at times. A more serious matter is the entire omission of an index, there being simply a table of contents covering barely two pages.

Publications Received.

BULLETINS, BUREAU OF THE CENSUS.—S. N. D. North, Director. Washington, D. C.: Pub. Doc. Paper; 9 × 11½ ins.
No. 89: Population of Oklahoma and Indian Territory, 1907. Pp. 43; one folding map.

BULLETINS, U. S. GEOLOGICAL SURVEY.—George Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.
No. 325: A Study of Four Hundred Steaming Tests Made at the Fuel-Testing Plant, St. Louis, Mo., in 1904, 1905 and 1906. By Lester P. Breckenridge. Pp. 196; 76 illustrations in the text.

BUREAU OF ORDNANCE.—Annual Report of Chief to the Secretary of the Navy, for the Fiscal Year 1907. (N. E. Mason, Chief of Bureau.) Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.; pp. 52.

CARBURETING AND COMBUSTION IN ALCOHOL ENGINES.—By Ernest Sorel. Translated from the French by Sherman M. Woodward, Formerly Professor of Steam Engineering, State University of Iowa, and John Preston. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5 × 8¼ ins.; pp. 269; 26 illustrations in the text. $3; English price, 12s., 6d., net.

COMMISSIONERS OF THE STATE RESERVATION AT NIAGARA.—Annual Report, from Oct. 1, 1905, to Sept. 30, 1906. (Edward H. Perry, Secy., Niagara Falls, N. Y.) Albany, N. Y.: Pub. Doc. Paper; 5¾ × 9 ins.; pp. 73; folding and other plates, and text figures.

ELECTRICAL TRACTION.—By Ernest Wilson, M. Inst. E. E., Professor of Electrical Engineering in the Siemens Laboratory, King's College, London, and Francis Lydall, Assoc. Inst. E. E. In two volumes. New York: Longmans, Green & Co. London, England: Edward Arnold. Cloth; 5½ × 8¾ ins. $4, net (each volume).
Vol. I.: Direct Current. Pp. 475; 271 illustrations, mostly in the text.
Vol. II.: Alternating Current. Pp. 328; 184 illustrations, mostly in the text.

ENGINE-ROOM CHEMISTRY.—A Compend for the Engineer and Engineman. By Augustus H. Gill, Ph. D., Associate Professor of Technical Analysis of the Massachusetts Institute of Technology, Boston, Mass., Author of "Gas and Fuel Analysis for Engineers," etc. New York and London: Hill Publishing Co. Cloth; 4½ × 7 ins.; pp. 198; 47 illustrations in the text. $1.

GEOLOGIC ATLAS OF THE UNITED STATES.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 18½ × 21½ ins.
No. 151: Roan Mountain Folio. Tennessee—North Carolina. Pp. 11; six plates and three text figures.
No. 152: Patuxent Folio. Maryland—District of Columbia. Pp. 12; three plates and two text figures.
No. 153: Ouray Folio. Colorado. Pp. 20; four plates and four text figures.

HANDBUCH FUER EISENBETONBAU.—Edited by F. von Emperger. Vol. II.: The Material and Its Manipulation. Prepared by K. Memmler, H. Burchartz, H. Albrecht, R. Janesch, O. Rappold, A. Nowak. Berlin, Germany: Wilhelm Ernst & Sohn. Paper; 7¼ × 10½ ins.; pp. 243; 420 text illustrations and 1 folding plate. 12 marks; American price, $4.80.

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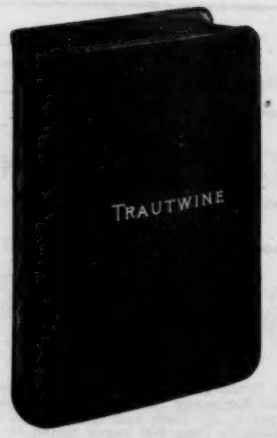

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